

have a nacreous appearance on account of the thickness of their muscular walls. These sacs end blindly and are not, as I at first thought them, the dilated ends of the muscular duct of the spermiducal glands. They occupy two or three segments and open on to the exterior in the xviiith segment through the penes. Their walls are excessively thick and the lumen therefore is not wide. The penis on to which each of them opens is a portion of the body-wall which projects; it does not appear to be simply the everted portion of the sacs. The extremity of the organ is vascular and has a wide lumen; but where it traverses the body-wall the lumen of the bursa is narrow. The two sperm-ducts become united just where they dip into the thickness of the walls of the bursa; they are ciliated on their passage through the bursa and open into its interior. The spermiducal glands have the structure which has been referred to in the definition of the genus. One pair of them opens into the bursa near to, but quite independently of, the orifice of the sperm-ducts; the other opens in front of this on to the xviiith segment. The accompanying diagram (woodcut, fig. 3) shows the relations of the different parts of the male efferent apparatus. The ovaries and oviducts are in the usual places for these organs to occupy. There is a single pair of spermathecæ in the viiith segment; they are long and tubular without a diverticulum. The very extremity of the pouch differs from the rest in that its walls are very thin; this is brought about by the absence or very slight development of the muscular layers and the thinness of the epithelium. Elsewhere the epithelium is tall and folded. The pouch was filled with spermatozoa, arranged in a peculiar fashion. The heads of the spermatozoa were attached to the cells lining the pouch and presented quite a regular appearance, so much so that they might easily be mistaken for cilia.

May 1, 1894.

Dr. A. GÜNTHER, F.R.S., Vice-President, in the Chair.

The Secretary read the following report on the additions to the Society's Menagerie during the month of April 1894:—

The total number of registered additions to the Society's Menagerie during the month of April was 160, of which 87 were by presentation, 6 by birth, 49 by purchase, 2 received in exchange, and 16 on deposit. The total number of departures during the same period, by death and removals, was 83.

Amongst these I wish to call particular attention to the collection of Mammals and Reptiles sent to us by Dr. J. Anderson, F.R.S., being the proceeds of his recent expedition to Egypt and Suakim.

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NOTICE.

The 'Proceedings' are issued in *four* parts, as follows:—

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	II.	" " " March and April, on August 1st.
	III.	" " " May and June, on October 1st.
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PROCEEDINGS

OF THE

GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

ZOOLOGICAL SOCIETY

OF LONDON,

FOR THE YEAR

1894.

PART III.

CONTAINING PAPERS READ IN

MAY AND JUNE.



OCTOBER 1st, 1894.

PRINTED FOR THE SOCIETY,
SOLD AT THEIR HOUSE IN HANOVER SQUARE.

LONDON:
MESSRS. LONGMANS, GREEN, AND CO.,
PATERNOSTER-ROW.

[*Price Twelve Shillings.*]

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The collection, when shipped by Dr. Anderson at Alexandria on the 13th March last, contained 42 specimens representing in all 19 species. They were all beautifully packed, and only one animal (a Hedgehog, *Erinaceus aethiopicus*) died during the voyage, while a single Gerbille was reported as missing. Besides the Long-legged Jackal, *Canis variegatus*, three other species of *Canis* belonging to the large-eared section of Fennecs are represented in the collection. There is also a beautiful Genet with a long black vertebral stripe, which I take to be *Genetta senegalensis*, and examples of two distinct species of Zorilla (*Ictonyx*). The Rodents of the genera *Gerbillus*, *Dipodillus*, *Acomys*, and *Isomys* I must leave Dr. Anderson to determine.

There can be no doubt that this fine collection will be of great use to Dr. Anderson in the preparation of his proposed work on the Zoology of Egypt.

Dr. Günther exhibited the hollow trunk of a Tree-Euphorbia (*Euphorbia grandidentis*) which a pair of Hornbills (*Buceros melanoleucus*) had selected for nidification. The trunk, with the female bird and eggs, had been obtained by Dr. Schönland in the neighbourhood of Grahamstown, Cape Colony, and transmitted by him to the British Museum. The female when taken was unable to fly and was simultaneously moulting all the wing- and tail-feathers, thus presenting the appearance of a half-fledged young bird. This specimen, therefore, confirmed the observation which had also been made on other species of the genus, viz. that the female Hornbills pass through a complete moult in the six or eight weeks during which they are imprisoned with their eggs and young.

Mr. W. Bateson exhibited several hundred specimens and coloured drawings of *Gonioctena variabilis*, a Phytophagous Beetle, from Granada, Spain, in illustration of discontinuous variation in colour. These specimens, which were to form the subject of a future paper, were exhibited in the fresh state, as, after death, their colours faded rapidly.

Dr. H. E. Sauvage (Director of the Station Aquicole, Boulogne-sur-Mer) exhibited a vertebra of what was believed to be the earliest known Snake yet discovered. It was from the Gault of Portugal.

The following papers were read:—

1. On the Echinoderms collected during the Voyage of H.M.S. 'Penguin' and by H.M.S. 'Egeria,' when surveying Macclesfield Bank. By F. JEFFREY BELL, M.A., Sec. R.M.S.

[Received March 5, 1894.]

(Plates XXIII.-XXVII.)

Mr. P. W. Bassett-Smith, Surgeon R.N., was, fortunately for marine zoology, appointed after her cruise had begun to H.M.S. 'Penguin,' Capt. W. U. Moore, who was under instructions to survey parts of North-west Australia and the Macclesfield Bank. Mr. Bassett-Smith had already had experience not only in collecting in the Eastern Seas, but of the sympathy his captain had in his work, while on this cruise he had the further advantage of the co-operation of the chief engineer, Mr. J. J. Walker, who, when Mr. Bassett-Smith joined the ship, had already commenced to make his extensive collection of Insects—a collection so extensive that he was able to give over to the Museum no less than 12,000 specimens.

The Trustees of the British Museum have already expressed¹ their appreciation of the services rendered by Messrs. Bassett-Smith and J. J. Walker while on the 'Penguin,' and it now only remains for the zoologist to do his work of description and cataloguing.

After the 'Penguin' was paid off Mr. Bassett-Smith had offered him the opportunity of paying on board H.M.S. 'Egeria,' Commander A. M. Field, yet another visit to Macclesfield Bank; and it was well he did so, for it was on this occasion that he obtained the most interesting and valuable part of his collection of Echinoderms. He secured, for example, a specimen of a new species of *Eudiocrinus* allied to *E. indivisus*, the type of which is now in the private collection of Mr. W. Percy Sladen; *Ophiopteron elegans*, known hitherto only in the Brock collection, was obtained in several dredgings; and *Ophiocrene enigma* is a type of Ophiuroid which is perfectly new.

Interesting and valuable as this collection of Echinoderms is, it has offered peculiar difficulties in working out. I have never before had passing through my hands a collection containing so large a proportion of young specimens, or, in other words, forms in which the specific characters stated in the diagnoses are not distinctly marked². In some cases the series has been sufficiently long and gradual to enable me to assign quite young examples to what I think is their correct species, but I have had to query a larger proportion of my determinations than I can allow to pass without this word of explanation, and a number of specimens have been merely referred to their genera.

¹ [Annual] Return [Parliamentary] British Museum, 1893, p. 83.

² I find that the essential part of these remarks is true also of the Crustacea.—14th June, 1894.

In fact I have had forced on me the conviction that Macclesfield Bank is a nursery; with a rim submerged 9 fathoms¹ beneath the surface any pelagic larvæ that will can enter within its boundary; being 76 miles long and 36 miles broad, it affords some opportunities for the larvæ to settle, and the average depth within the rim is from 40 to 50 fathoms.

I may therefore suggest that it is of great importance that as full collections as possible should always be made in areas resembling the inside of this reef, for not only are questions of synonymy to be by this means settled, but the more interesting study of the changes that occur during growth can only be carried on with extensive series, the relationships of species can be more satisfactorily considered, and material be brought together of immense value to the morphologist.

It would be quite possible so to arrange the material for this paper as to make it of intolerable length, but I think I can so dispose of it as to bring all I have to say within reasonable compass.

I propose to give three lists:—(A) of the species from N.W. Australia; (B) of those from the Arafura and Banda Seas; and (C) of those from the Macclesfield Bank, in all of which the observed range in depth will be duly noted; after each species I place the name of the author who first described it. After these lists I give notes and descriptions in systematic order.

The point of greatest interest is the discovery that the sygyial joints at the bases of the arms of Comatulids by no means exhibit the regularity which is ordinarily believed to be one of their chief characteristics and their best claim to be used as aids and guides to the grouping of the species—that is to say, they have been taken as being very much more valuable than mere specific characters. *Antedon bassett-smithi* (see p. 399) shows how the syzygies may vary in one individual specimen; while the broken and nameless *Actinometra* (see p. 402) is positively appalling to a student of Comatulids, for it has no syzygy on either second or third brachial.

Where there is no large series it is very difficult to speak with any confidence as to the significance of unexpected irregularities, which may, of course, be merely individual, but, in systematic zoology, we have to beware always of the influence of generalizations based on material which is always becoming proportionately smaller. The general acceptance of Dr. P. H. Carpenter's classification removes the "idol" from the category of "idola specus" to that of "idola fori"; but we must not only remember, we must always keep before ourselves the doctrine of Macleay that "no character is natural until it has been proved to be so."²

This is, of course, saying in as many words that there is no

¹ See Bassett-Smith, Ann. & Mag. Nat. Hist. vi. (1890) p. 356.

² See J. D. Macdonald in Trans. Linn. Soc. xxiii. p. 75. Pupils of the late Prof. Rolleston need not be told whence I derived my knowledge of this principle.

fixity of tenure in zoology, no certainty that the doctrines accepted to-day will not be derided to-morrow; most men of science see this and act accordingly; the systematic specialist is apt to forget it, and to bear himself as though the motto of his science were "Quod semper, quod ubique, quod ab omnibus."

I cannot but hope that the description I have given of the very remarkable Ophiuroid which I have called *Ophiocrene enigma* will result in the search for more, and perhaps more fully matured, specimens; it is a matter of regret that the material is not sufficient to allow of a complete judgment as to the systematic position of what all will allow to be a very remarkable form.

A.—List of Echinoderms of North-west Australia¹.

I. HOLOTHURIOIDEA.

	Observed range in depth.
<i>Colochirus tuberculosus</i> , <i>Semper</i>	15-36 fms.
<i>Actinocucumis typica</i> , <i>Ludwig</i>	15-20 "

II. CRINOIDEA.

<i>Antedon milberti</i> , <i>Müller</i>	8-15 fms.
" <i>serripinna</i> , <i>P. H. C.</i>	24-39 "
" <i>variipinna</i> , <i>P. H. C.</i>	9-38 "
" sp. (near <i>macronema</i>)	?
<i>Actinometra pectinata</i> , <i>Retz</i>	20-36 "
" <i>nobilis</i> , <i>P. H. C.</i>	65 "
" <i>paucicirra</i> , <i>Bell</i>	8-15 "
" <i>parvicirra</i> , <i>P. H. C.</i>	9 "
" <i>variabilis</i> , <i>Bell</i>	9-38 "
" <i>multifida</i> , <i>Müller</i>	?
" <i>multiradiata</i> , <i>L.</i>	?

III. ASTEROIDEA.

<i>Astropecten polyacanthus</i> , <i>M. Tr.</i>	32-34 fms.
" <i>schoenleini</i> , <i>M. Tr.</i>	?
" <i>zebra</i> , <i>Sladen</i>	8-36 "
<i>Luidia hardwickii</i> , <i>Gray</i>	36 "
" <i>aspera</i> ?, <i>Sladen</i>	15-38 "
<i>Iconaster longimanus</i> , <i>Möbius</i>	15-38 "
<i>Stellaster inaequalis</i> , <i>Gray</i>	8-34 "
<i>Pentaceros nodulosus</i> , <i>Perrier</i>	15 "
<i>Culcita pentangularis</i> , <i>Gray</i>	?
<i>Ophidiaster heliostichus</i> , <i>Sladen</i>	15-24 "
<i>Linckia marmorata</i> , <i>Michelin</i>	15-22 "
" <i>megaloplax</i> , <i>Bell</i>	15-24 "
<i>Nardoa tuberculata</i> , <i>Gray</i>	9-38 "
<i>Metrodira subulata</i> , <i>Gray</i>	39 "
<i>Echinaster purpureus</i> , <i>Gray</i>	8-15 "

IV. OPHIUROIDEA.

<i>Pectinura megaloplax</i> , <i>Bell</i>	?
" <i>sphenisci</i>	15 fms.

¹ The chief localities are Holothuria Bank, Magnetic Shoal, Cossack Island; and Baudin Island (14° 8' S., 125° 36' E.).

<i>Ophiopeza conjungens</i> , <i>Bell</i>	38 fms.
<i>Ophiolepis annulosa</i> , <i>M. Tr.</i>	24 "
<i>Ophionereis dubia</i> , <i>M. Tr.</i>	8-36 "
<i>Ophiothrix longipeda</i> , <i>M. Tr.</i>	15 "
" <i>martensi</i> , <i>Lyman</i>	15-34 "
" <i>melanogratuma</i> , <i>Bell</i>	36 "
" <i>melanosticta</i> , <i>Grube</i>	38 "
" <i>smaragdina</i> , <i>Studer</i>	9 "
" <i>trilineata</i> , <i>Lütke</i>	20-35 "
<i>Ophiomaza cacaotica</i> , <i>Lyman</i>	8-20 "
" <i>obscura</i> , <i>Lyman</i>	9 "
<i>Astrophyton clavatum</i> , <i>Lyman</i>	?
<i>Euryale aspera</i> , <i>Lamk.</i>	8 "

V. ECHINOIDEA.

<i>Phyllacanthus annulifer</i> , <i>Lamk.</i>	8-15 fms.
<i>Diadema saxatile</i> , <i>L.</i>	12-15 "
<i>Temnopleurus bothryoides</i> , <i>Ag.</i>	40-47 "
<i>Saluacis sulcata</i> , <i>Ag.</i>	12 "
<i>Echinanthus testudinarius</i> , <i>Gray</i>	32-44 "
<i>Laganum decagonale</i> , <i>Less.</i>	20 "
" <i>depressum</i> , <i>Ag.</i>	15 "
<i>Lovenia elongata</i> , <i>Gray</i>	34-36 "
<i>Breynia australasica</i> , <i>Leach</i>	?

B.—*Echinoderms of the Arafura and Banda Seas.*

I. HOLOTHURIOIDEA.

0.

II. CRINOIDEA.

Actinometra maculata, *P. H. C.* (Parry Shoal, 12 fms.)

III. ASTEROIDEA.

Astropecten polyacanthus, *M. Tr.* (Evans Bank, 12-15 fms.)
Linckia megaloplax, *Bell.* (Parry Shoal; Damma Id., 9-15 fms.)
Scytaster novæ-caledoniæ, *Perrier.* (Damma Id.)
Nardoa tuberculata, *Gray.* (Parry Shoal.)

IV. OPHIUROIDEA.

Ophioplocus imbricatus, *M. Tr.* (Damma Id.)
Ophiolepis irregularis, *Erock.* (Damma Id.)
Ophiocoma scolopendrina, *Lamk.* (Franklin Shoal, 9 fms.; Flinders Bank, 9 fms.; and Evans Bank, 12-15 fms.)
Ophiocoma pica, *M. Tr.* (Flinders Bank, 9 fms.)
Ophiothrix punctolinbata, *Mart.* (Parry Shoal, 12 fms.)
Ophiomyxa australis, *Ltk.* (Flinders Bank, 9 fms.)
Euryale aspera, *Lamk.* (Parry Shoal, 12 fms.)

V. ECHINOIDEA.

Cidaris baculosa, *Lamk.* (Parry Shoal, 12 fms.; Damma Id., 9-15 fms.)
Diadema saxatile, *L.* (Evans Bank, 12-15 fms.)
Salmacis globator, *A. Ag.* (Damma Id., 9-15 fms.)
 " *sulcata*, *Ag.* (Parry Shoal, 12 fms.)
Echinometra lucunter, *Leske.* (Damma Id., 9-15 fms., and between tide-marks.)

C.—*Echinoderms from Macclesfield Bank.*

I. HOLOTHURIOIDEA.

	Observed range in depth.
<i>Colochirus tuberculosus</i> (? yg.), <i>Semper</i>	45 fms.

II. CRINOIDEA.

<i>Eudiocrinus granulatus</i> , sp. nov.	34-40 fms.
<i>Antedon carinata</i> , <i>Lam.</i> (? jr.)	29-32 "
" ? <i>spicata</i> , <i>P. H. C.</i>	20-35 "
" <i>inopinata</i> , sp. nov.	31-36 "
" <i>bassett-smithi</i> , sp. nov.	13-36 "
" <i>vicaria</i> , sp. nov.	30-40 "
" <i>brevicirra</i> , sp. nov.	20-35 "
" <i>flavomaculata</i> , sp. nov.	13 "
" <i>moorei</i> , sp. nov.	13 "
" <i>fieldi</i> , sp. nov.	22-30 "
" sp. n. inq.	?
" sp. n. inq.	?
" ? <i>variispina</i> , <i>P. H. C.</i>	50 "
<i>Actinometra fimbriata</i> , <i>Lam.</i>	22-45 "
" <i>parvicirra</i> , <i>Müll.</i>	10-36 "
" <i>bennetti</i> , <i>Bölsche</i>	13 "
" <i>simplex</i> , <i>P. H. C.</i>	13 "
" ? <i>duplex</i> , <i>P. H. C.</i>	13 "
" <i>maculata</i> , <i>P. H. C.</i>	13-36 "
" <i>rotalaria</i> , <i>Lam.</i>	13-36 "
" <i>regalis</i> , <i>P. H. C.</i>	30 "
" <i>peregrina</i> , sp. nov.	55-60 "

III. ASTEROIDEA.

<i>Archaster typicus</i> , <i>M. Tr.</i>	23-50 fms.
" <i>tenuis</i> , sp. nov.	35-41 "
<i>Astropecten polyacanthus</i> , <i>M. Tr.</i>	30-41 "
<i>Luidia</i> ? <i>aspera</i> (yg.), <i>Sladen</i>	20-35 "
" <i>forficifer</i> , <i>Sladen</i>	30-40 "
" <i>hardwickii</i> , <i>Gray</i>	31-37 "
" <i>longispinis</i> , <i>Sladen</i>	30-45 "
" <i>maculata</i> (yg.), <i>M. Tr.</i>	30-41 "
<i>Goniodiscus rugosus</i> (yg.), <i>Perr.</i>	45 "
<i>Culcita</i> (yg.), sp. nov.	40-50 "
<i>Patiria briareus</i> , sp. nov.	30-45 "
<i>Chætaster moorei</i> , sp. nov.	36-40 "
<i>Asterina cepheus</i> , <i>M. Tr.</i>	17-30 "
<i>Fromia milleporella</i> , <i>Lamk.</i>	22-40 "
<i>Leiaster</i> ? <i>leachi</i> (yg.), <i>Gray</i>	41-44 "
" <i>speciosus</i> (yg.), <i>Mart.</i>	41-44 "
<i>Nardoa tuberculata</i> , <i>Gray</i>	30-46 "
<i>Rhipidaster</i> ? <i>vannipes</i> , <i>Sladen</i>	32 "
<i>Mithrodia clavigera</i> , <i>Lamk.</i>	41-44 "
<i>Echinaster purpureus</i> , <i>Gray</i>	29-40 "
<i>Asterias volsellata</i> , <i>Sladen</i>	32 "

IV. OPHIUROIDEA.

<i>Pectinura elegans</i> , sp. nov.	13-35 fms.
" <i>infernalis</i> ?, <i>M. Tr.</i>	17 "
<i>Amphiura olivacea</i> , <i>Brock</i>	30-40 "
<i>Ophiocoma pica</i> , <i>M. Tr.</i>	17 "

<i>Ophiocoma scolopendrina</i> , <i>M. Tr.</i>	30-40 fms.
<i>Ophiarachna clavigera</i> , <i>Brock</i>	32 "
<i>Ophiomastix caryophyllata</i> , <i>Lütke</i>	17 "
<i>Ophiothrix capillaris</i> , <i>Lyman</i>	41-44 "
" <i>melanogramma</i> , <i>Bell</i>	35-41 "
" <i>purpurea</i> , <i>v. Martens</i>	23-46 "
" <i>comata</i> (et var.), <i>M. Tr.</i>	30-35 "
" <i>punctolimbata</i> ? (yg.), <i>v. Martens</i>	5 "
" <i>rotata</i> ? (yg.), <i>v. Martens</i>	5 "
<i>Ophiopteron elegans</i> , <i>Ludw.</i>	23-47 "
<i>Ophiomyxa australis</i> , <i>Lütke</i>	31-39 "
" <i>brevispinis</i> , <i>v. Martens</i> ¹	13-72 "
" <i>longipeda</i> , <i>Brock</i>	29-32 "
<i>Ophiocrene ænigma</i> , sp. nov.	45 "

V. ECHINOIDEA.

<i>Cidaris baculosa</i> , <i>Lamk.</i>	30-44 fms.
" <i>metularia</i> , <i>Lamk.</i>	26-46 "
<i>Diadema saxatile</i> , <i>Linn.</i>	34-46 "
<i>Astropyga radiata</i> , <i>Leske</i>	30-40 "
<i>Temnopleurus toreumaticus</i> , <i>Leske</i>	?
" <i>reynaudi</i> , <i>Ag.</i>	50 "
" <i>bothryoides</i> , <i>Ag.</i>	40-47 "
<i>Salmacis rufa</i> , sp. nov.	30-44 "
<i>Mespilia globulus</i> , <i>Linn.</i>	13-34 "
<i>Tripneustes gratilla</i> , <i>Linn.</i>	30-40 "
<i>Pseudoboletia maculata</i> , <i>Troschel</i>	45 "
<i>Clypeaster scutiformis</i> , <i>Gmel.</i>	30-40 "
<i>Laganum decagonale</i> , <i>Less.</i>	20 "
<i>Echinoneus cyclostomus</i> , <i>Leske</i>	30-40 "
<i>Arachnoides placenta</i> , <i>Linn.</i>	35-41 "
<i>Lovenia elongata</i> , <i>Gray</i>	35-41 "

I now proceed to give descriptions of the new species represented in the present Collection, and notes on others previously described.

I. HOLOTHURIOIDEA.

It is remarkable that the collection of Holothurians should be so very scanty; Mr. Bassett-Smith tells me that it always struck him "as being a most remarkable thing that in the 100 odd dredgings on the Macclesfield Bank and China Sea only two minute specimens were obtained."

II. CRINOIDEA.

EUDIOCRINUS GRANULATUS, sp. nov. (Plate XXIII.)

Like *E. indivisus*² in having the first two brachials united by syzygy and the first pinnule on the left side of the second brachial.

¹ As pointed out by Brock (Zeit. f. w. Zool. xlvii. p. 530), this species is omitted by Mr. Lyman from his 'Challenger' Report; I doubt if research will ever find another case of omission. It may be useful to add the original reference; it is Arch. f. Nat. xxxvi. (1870) p. 249.

² See P. H. Carpenter in Journ. Linn. Soc., Zool. xvi. (1883) p. 495.

But the whole creature is much stouter altogether, with longer, stronger cirri, wider arms, much stronger pinnules, and a granular covering to the joints. It has a spread of 240 mm., and the cirri are about 12 mm. long. The arrangement and number of the cirri is as described for *E. indivisus*; indeed there are many points in a written description of the one species which would hold for the other. However, in the new species the first two pinnules have more massive joints than the third and fourth and are quite as long, the second, indeed, being longer than the third. The other striking point of difference is the granulation of the surface of the basal joints of the arms.

From the descriptions of Semper and P. H. Carpenter, bearing in mind that they had only one specimen and I only one, I was inclined to regard the Macclesfield Bank specimen as belonging to Semper's species; but when I was, by the kindness of Mr. W. Percy Sladen, enabled to put the new specimen side by side with Semper's type, which is now in his possession, it was easy to see that the two could not be united.

The syzygial union of the first two brachials would of itself separate *E. granulatus* from the three species described by Carpenter, but they are, further, all much stouter than *E. granulatus*, though the latter is itself very much stouter than *E. indivisus*, which is quite delicate.

Of the latter, Dr. Herbert Carpenter says, "colour of skeleton brownish white;" it is now (January 1894) quite white; in the new species the ambulacral surface of the pinnules is a purplish brown, the rest yellowish white.

The single specimen, which is in fairly good condition, was dredged at a depth of 34-40 fathoms off Macclesfield Bank.

ANTEDON INOPINATA, sp. nov.

This species stands closest to the late Dr. Herbert Carpenter's *granulifera*-group, but it is distinguished from both sections thereof by having a syzygy in the third brachial.

Centrodorsal large, hollowed in the centre, which is bare of cirrus-pits; the cirri in three irregular rows on the side, long and stout, but not composed of so many as forty joints, variable in length, and about forty-five in number; the terminal joints faintly spinous.

About forty-five arms, the joints of which are much compressed from side to side. The first and second radials are wide and stout, the third is short at the sides; there are three distichals of which the axillary is a syzygy; the arms nearly always divide again, when there are three palmars, of which the axillary is a syzygy; in rare cases there are also two post-palmars. The pinnules generally are pretty stout and stiff, the basal one very markedly stout. There is a syzygy on the third brachial, but not again for about twenty-five joints; the arm-joints are wide, low, and very regular.

Colour, in spirit, light brown, the ambulacral surface of the pinnules somewhat darker.

Arms about 100 mm. long; diameter of disc 10 mm.; length of cirri up to 28 mm.

Macclesfield Bank, 31-36 fms. H.M.S. 'Penguin.'

ANTEDON BASSETT-SMITHI, sp. nov. (Plate XXIV.)

This is one of the late Dr. H. Carpenter's *spinifera*-group, and belongs to that section in which there are from fifteen to twenty-five cirrus-joints. The cirri are not arranged in definite rows, and the sides of the distichals are not flattened.

Centrodorsal rather large, slightly hollowed in the centre, which is bare of cirrus-pits; the cirri in three planes at the side, about forty in number, with from twenty to twenty-five joints, some of which are considerably elongated; in the distal half they have a slightly projecting free edge, but there is no distinct spine.

Arms, probably, more than forty in number, stout, widely separated at their bases, where the disc-incisions are deep. First radial obscured, the second wide, the third almost triangular; two distichals, two palmars; the latter may or may not be united by syzygy. In the syzygies of the arms the most extraordinary variations occur: sometimes the first two brachials are united by syzygy, sometimes (to use the usual terminology) the third is a syzygy, sometimes both first and second and third are. The first arm-joints are squarish, the succeeding alternately wider and narrower on either side. The second and third pinnules ordinarily have the two basal joints much wider than the rest and of a characteristic shape (Plate XXIV. figs. 5 & 6); none of the pinnules are either stout or long.

I must confess that I am quite at a loss to know how to explain the extraordinary divergencies exhibited by the syzygies of this species. It is, of course, a great pity that there is only a single example of it, and it would be rash to say that it destroys the generalizations to which long study of a number of species and specimens led Dr. H. Carpenter; but, on the other hand, it cannot but shake our belief in the universality of the conclusions drawn up by Carpenter on pp. 44-46 of the 'Challenger' Report on the 'Comatulæ.' If it be merely an abnormality it is a case in which monstrosity is really carried too far, and is one that is, probably, quite unequalled by any known Crinoid. So far as I know, and, indeed, so far as I can, after diligent search, discover, the only recorded case of striking irregularity in the position of the syzygies is that of the Göttingen specimen of *Antedon macronema*, of which Dr. C. Hartlaub remarks¹:—"Bemerkenswerth ist an ihm die unregelmässige Lage der ersten Syzygie, die zwischen dem 3. 4. und 6. Brachiale wechselt." But here we have not only two conditions which have been supposed to be mutually exclusive in different arms of one specimen, but these very two conditions occur on one arm. Did we know something of the function of the syzygies, it would be easier to come to a decision, but as our knowledge of that function appears to be summed up in the state-

¹ Nova Acta Acad. Cæs. L.-C. lviii. no. 1, p. 78 (Halle, 1891).

ment that the syzygial mode of union makes the arms more fragile at the points where it occurs, those who believe in the efficiency of Natural Selection will not accept the view that this doubling of the syzygies is of advantage to the possessor.

I hope, therefore, that the peculiarities of this specimen (I will not say of this species) may come under the notice of those who work at Crinoids, and that material may be gathered sufficient for us to make up our minds as to whether we have to do with an individual eccentricity or a true character specifically distinctive of its possessor.

There remain to be noticed five bidistichate species with more than ten arms of which I cannot give full descriptions, as the single specimens by which they are represented are not always well preserved. Diagnoses, however, are possible.

They may be thus arranged, in accordance with Dr. H. Carpenter's scheme on pp. 211, 212 of the Report on the 'Challenger' Comatulæ:—

- | | |
|---|-------------------------------------|
| A. Over 30 cirrus-joints..... | i. <i>Antedon vicaria</i> . |
| B. 30 or less than 30 cirrus-joints. | |
| Cirri without definite arrangement. | |
| Flattened { 25 cirri of 9 joints each | ii. <i>Antedon brevicirra</i> , |
| sides to { About 30 cirri of 16 smooth joints ... | iii. <i>Antedon flavomaculata</i> . |
| brachials. { | |
| Sides { Faint spinous process on later cirrus- | iv. <i>Antedon moorei</i> . |
| hardly { joints..... | |
| flattened. { Very broad spinous process on later | v. <i>Antedon fieldi</i> . |
| { cirrus-joints | |

ANTEDON VICARIA, sp. nov.

Bidistichate, with wall-sided radials, strong pinnules, and about 30 cirrus-joints, of which the more distal are spiny. With so much resemblance to *A. macronema*, it has shorter cirri (20 mm.) and has numerous (30) joints. Arms probably about 25 in number. Neither radial nor distal palmar syzygial. Cirri white, arms white with middle dorsal line of purple, pinnules purplish.

Spread 100 mm.; diameter of deeply incised disc 4 mm.

Macclesfield Bank, 30–40 fms.

ANTEDON BREVICIRRA, sp. nov.

Bidistichate, with flattened sides to brachials, 25 cirri of 9 joints, rather more than 40 arms, and a long first pinnule.

Colour light brown.

Macclesfield Bank, 20–35 fms.

This species is so much broken that I should not have described it did I not wish to call attention to the short cirri set at the edge of the disc, recalling in every way the cirri of an *Actinometra*.

ANTEDON FLAVOMACULATA, sp. nov.

Bidistichate, with (in the single known specimen) exactly 20 arms; about 30 cirri, with 16 smooth joints, and the centre of the

low centrodorsal bare of cirrus-sockets. The first syzygy is on the third brachial, the next on or about the thirteenth. The most proximal brachials are square, those that succeed them are triangular. The second pinnule is very long and stiff, much longer than the first or third. Arms purplish, with yellowish dots and patches; the cirri yellowish at base and purplish at tip.

Spread 120 mm.; diameter of disc 6 mm.

Macclesfield Bank, 13 fms.

ANTEDON MOOREI, sp. nov.

This species is probably most nearly allied to *A. compressa*, P. H. C., but it has only faint spinous processes on the cirrus-joints. Cirri 25 to 30, with 25 joints. Centrodorsal bare in the middle. No syzygies on radials, distichals, or palmars. There may be post-palmars. The third brachial syzygial; arm-joints iii.-vi. squarish, the succeeding triangular, and the more distal gradually overlapping.

Colour purplish, with the free ends of the arms white.

Macclesfield Bank, 13 fms.

The single specimen is a good deal broken, but it is interesting as belonging to a series of the group of which Dr. Carpenter knew only one type.

ANTEDON FIELDI, sp. nov.

Allied to *A. moorei*, but distinguished from it by the broad spine on the cirrus-joints. Cirri about 20, with 18 joints, almost completely covering the centrodorsal. No syzygy on radials or distichals; the first on the third brachial.

Colour bright purple with lighter cirri.

Macclesfield Bank, 22-30 fms.

I offer a brief diagnosis of this species, as the peculiarity of the broad spines on the cirrus-joints ought to be known.

I associate with these two species the names of the commanding officers of H.M. ships 'Penguin' and 'Egeria,' Captain W. U. Moore, R.N., and Commander A. M. Field, R.N.

There is yet another bidistichate species, which is altogether too much broken for description (13 fms., Macclesfield Bank), which has about 30 cirri and 20 smooth cirrus-joints. There are distinct signs that a re-arrangement of the useful key given by Carpenter of the "Spinifera-group" will soon be needed. Considering the large number of new species assignable to this group found by Mr. Bassett-Smith, I cannot but wonder that none were found by the lamented Dr. Brock in his expedition to Amboina, the neighbouring region. I do not know what led Dr. C. Hartlaub to say of the group that it "umfasst . . . Formen, die in Wesentlichen dem Caraischen Meere angehören"¹, but it was not the then known facts of distribution; still less is the statement accurate after the discoveries at Macclesfield Bank.

¹ *Op. cit.* p. 75,

ACTINOMETRA PEREGRINA, sp. nov.

This species belongs to Carpenter's series II. (*tom. cit.* p. 300), every known species of which, except *A. cumingi* (from Malacca and Queensland) and *A. echinoptera* (of unknown habitat), belongs to the West Indian fauna. From the two species just named *A. peregrina* may be at once distinguished by the characters of its cirri, for whereas *A. echinoptera* has cirri with eleven joints the new species has as many as twenty-five, while there are at least twenty-five cirri arranged in two rows, and not twelve only arranged in one as in *A. cumingi*.

The following characters will serve to diagnose the species:—

Centrodorsal moderately large and a good deal obscuring the radials; bare in its middle, with about 25 cirrus-pits, the cirri of moderate length with about 25 joints, of which the 5th and 6th seem to be distinctly the longest. The basal joints of the arms very irregular, and no two alike; the free edge of the joints soon become very finely denticulate. The first syzygy is on the third brachial, the succeeding on the eleventh and eighteenth. Pinnules remarkably well developed even at some distance from the base of the arms.

Colour brownish.

Macclesfield Bank, 55-60 fms.

Mention also must be made of an *Actinometra* to which I think it would be wrong to give a specific name, so broken is it, but of which it would be more wrong not to say something. It will be remembered that the late Dr. H. Carpenter divided the tridistichate species of this genus into those in which there is a syzygy on the second brachial and into those that have it on the third. In the specimen now before me there is no signs of any syzygy on either the second or the third brachial.

This is another very remarkable fact, and it is most important that we should obtain several specimens of this form, so as to learn whether the absence of syzygies from both second and third brachials is a constant character. If it is, it is certainly one of the most unexpected results, and taken in conjunction with what has been observed in *Antedon bassett-smithi* it will severely shake our faith in the value of the site of the syzygy as an aid in specific diagnosis.

III. ASTEROIDEA.

ARCHASTER TYPICUS.

Archaster typicus, M. Tr. Ber. Ak. Berlin, 1840, p. 104.

In two small specimens dredged, with a large example, in 23-24 fms. of water there are no signs of any spines on the infero-marginal plates; in a somewhat larger specimen (from 40-46 fms.) there are on some of the plates indications of the growth of spines.

ARCHASTER TENUIS, sp. nov. (Plate XXV. figs. 4-6.)

This seems to be a species of *Archaster* in the sense of

Mr. Sladen, who has cleared from the genus a number of species that do not appear to belong to it.

$$R=40, r=6; \text{ or } R \text{ nearly}=7r.$$

Arms very delicate, only 5 mm. wide at their base, with about 45 marginal plates; the supero-marginals nearly twice as deep as wide at base, but gradually becoming more shallow, so that they are nearly square in the distal two-thirds of the arm. The infero-marginals ordinarily have one spine long enough to reach the upper surface of the supero-marginal; occasionally there is a second smaller, but still evident spine. The adambulacral armature is diplacanthid, and there are ordinarily three divergent spines in each row.

On the upper surface "the medioradial line of plates" becomes somewhat indefinite in the distal portion of the arm.

It is not easy to be sure that the specimen from which this description is drawn up is mature; it is, at any rate, old enough to have lost one arm and part of another; the latter has already begun to repair itself. There were taken at the same dredging (35-41 fms.) several obviously young specimens of this species; they have a marked *Astropectinine* appearance, owing doubtless to the fact that the medioradial line has not yet been differentiated.

LUIDIA MACULATA.

Luidia maculata, M. Tr. Syst. Ast. (1842) p. 77.

All the specimens collected were of small size.

LUIDIA LONGISPINIS?

Luidia longispina, Sladen, Chall. Rep. Ast. xxx. p. 254 (1890).

I have not much hesitation in referring several young specimens to this species.

LUIDIA FORFICIFER.

Luidia forficifer, id. op. cit. p. 258.

I have been able to recognize this species of Mr. Sladen's in Mr. Bassett-Smith's collection; the types come from or near Torres Strait.

LUIDIA sp.

I am unable to assign to any described species known to me three young specimens, which have suffered a considerable loss of arms and have undergone repair by gemmation.

GONIODISCUS sp.

There was taken at a depth which cannot now be certainly ascertained a young specimen of what may perhaps prove to be a juvenile example of *G. rugosus*, Perrier.

CULCITA sp. (Plate XXVI. fig. 1.)

A quite young, nearly spherical, specimen with a diameter of

12 mm. was taken between 40 and 50 fms. on Macclesfield Bank. I have had an enlarged figure drawn by Mr. Berjeau, as I hoped to be able to get some light on the morphology of the skeleton; but I must own myself very much disappointed.

If I have correctly identified the plate I have marked C as the representative of the central plate of a typical calyx, it is clear that we have here an unsymmetrical central plate, for it has neither five sides nor ten, and the line of plates connecting it with the terminal (T) is so curved that it seems to be fanciful to compare it in any way with an arm of a Crinoid. In the intermediate plates there is neither order nor symmetry apparent to me; but as others may be better endowed with sagacity than myself, I give the figure in the hope that it may be of some service.

PATIRIA BRIAREUS, sp. nov. (Plate XXV. figs. 1-3.)

It is with the greatest hesitation that I refer to this genus the very curious specimens dredged between 30 and 46 fathoms off Macclesfield Bank, which have seven or eight arms, and which, therefore, if correctly assigned generically, are appropriately called *briareus*.

It is very difficult to find specific characters.

$$R = 6.3 r.$$

Arms taper very gradually, with rather straight deep sides, and flat actinal surface; adambulacral spinulation monacanthid, about five spines to each plate. The plates on the upper surface are very inconstant in shape, the papular pores among them are rarely anything but solitary. Madreporite obscure. Colour in spirit brownish, lighter when dry.

$R=38, r=6$. Breadth of arm at base 6. Depth 5.

$R=29, r=6$. Breadth of arm at base 5.5. Depth 4.5.

This is, I am aware, a very slight description; but, as I have already said, it is extremely difficult to find any specific characters; what is most remarkable is that every one of the specimens exhibits restoration of the arms by budding. In one there are three complete and subequal arms and four papilliform growths together; another has four subequal arms and four very much smaller, of the latter one is a good deal shorter than the rest; in a third there are three longer arms and four shorter arms, and in a fourth these latter (again four in number) are a good deal longer than in the preceding specimen—in both these cases the shorter arms were neighbours. In another example there is a group of four subequal arms which are hardly shorter than the other three; in the last case the eighth arm is much shorter than any of the others.

CHÆTASTER MOOREI, sp. nov.

$$R = 6 r.$$

Disc small; arms elongate, high and straight at the sides, tapering very gradually; they are made up of thirteen very regular rows of plates, some of which have rising from their centre a

sharp spine; the plates that bear such spines are most numerous near the bases of the arms. There are eight fine spines bordering the narrow ambulacral groove, the shortest of which are at the sides, and the whole set of which forms a fan-like expansion; there follow on these four upright and stouter spines. The arm-plates are covered with fine projecting glassy spines, which, on the disc, are blunt.

$R=87.5$, $r=9.5$. Breadth of arm at base 7.5 . Height of arm 7.5 .

Macclesfield Bank, 30–40 fms.

If I am right, which I very much doubt, in assigning this species to the genus *Chataster*, the diagnosis of the genus will have to be so far altered as to include the possible possession by the plates of the arms of central projecting spines. A difference in the combination of circumstances makes it sometimes right, sometimes wrong, to form a new genus or a new species on the evidence afforded by a single specimen; in the present case I can only briefly give the evidence of the existence of a type hitherto unrecognized.

OPHIDIASTER HELICOSTICHUS.

Ophidiaster helicostichus, Sladen, Chall. Rep. Ast. xxx. p. 405.

Two fine specimens, one from Holothuria Bank (15 fms.) and the other merely reported as from N.W. Australia, are so much larger than the specimens which I have referred to my *Linckia megaloplax*, that I cannot assert that they are all members of one species, but I have very little doubt on the point.

RHIPIDASTER VANNIPES.

Rhipidaster vannipes, Sladen, Chall. Rep. Ast. xxx. p. 448.

I am inclined to think that two small specimens, one of which is quite minute, from 32 fms. may, when a full series is obtained, be shown to be the young of this species founded on a single specimen, the spread of which is more than 170 millim. Between them at present it seems useless to make a comparison. Both the small specimens have nine arms.

ASTERIAS VOLSELLATA.

Asterias (Stolasterias) volsellata, Sladen, Chall. Rep. Ast. xxx. p. 584.

A small example of this species, the only other known example of which is the one that formed the basis of Mr. Sladen's description, is another of the finds on which Mr. Bassett-Smith is to be congratulated. The whole spread of this new specimen is less than 30 millim., but its *Brisinga*-like appearance is no more marked than that of the "type."

It has unfortunately been in recent years so rare an occurrence for me to be able to agree with the views of the describer of this species, that I gladly seize the opportunity of saying that he seems

to me to be fully justified in regarding *Asterias volsellata* as a sign that the difference between the Asteriidae and Brisingidae is not so great as has been generally supposed. If I do not accept his view of the origin of the latter family, it is only because my capacities are not sufficient for me to be able to understand how it has been possible for "complete isolation" to have had an "action" on them. On this point I, and I believe many others, would be glad of a more detailed explanation.

The "type" is said to have come from 95 fms., and Mr. Bassett-Smith's example from 45 fms.

IV. OPHIUROIDEA.

PECTINURA SPHENISCI, sp. nov. (Plate XXV. figs. 7-9.)

This species stands with *P. spinosa*, *P. arenosa*, *P. infernalis*, and *P. heros*, of Mr. Lyman's arrangement, and *P. capensis*, Bell; for it has the disc covered under its granulation with coarse scales (much coarser than in *P. capensis*), and there are no pores between the under arm-plates. There are five or six short arm-spines and two tentacle-scales.

Radial shields not constant, but the typical arrangement probably is that they are small, naked, triangular, and separated from one another by a third triangular plate. The granulation of the disc is coarse, and the peripheral plates large. The arms are not wider at their base than at some distance outside the disc, nor carinated; accessory mouth-shields moderate in size, irregularly oval or quadrate. Six quite short arm-spines; fourteen mouth-papillæ. As often is the case the outermost is by far the smallest, and the penultimate distinctly the largest of the series. Mouth-shields almost triangular; granulated space between mouth-papillæ and shield well-marked.

The side arm-plates encroach on both the upper and lower surfaces; the upper arm-plates are wider distally than proximally, and the lower are irregularly hexagonal.

Ground-colour, when drying, greyish, with brown patches on disc and regular bands of brown extending over three or four joints on upper surface; lower surface uniformly pale.

Diam. of disc 5.5 mm.; length of arm about 40 mm.

Holothuria Bank, 15 fms.

PECTINURA ELEGANS, sp. nov.

This species belongs to Mr. Lyman's second division; but differs from all in having no pores between the under arm-plates. There are six rather short, moderately stout arm-spines and two tentacle-scales.

Radial shields naked, quite distinct, moderate in size, darker than the rest of the test; granulation rather fine, similar over the whole of the dorsal surface of the disc. The arms taper very gradually from their base; accessory mouth-plates small, semi-

1 mm. 5 mm. 10 mm. 15 mm. 20 mm. 25 mm. 30 mm. 35 mm. 40 mm. 45 mm. 50 mm. 55 mm. 60 mm. 65 mm. 70 mm. 75 mm. 80 mm. 85 mm. 90 mm. 95 mm. 100 mm.

Ne-

oval. Twelve month-papillæ to each angle of the jaw; a single row of large granules between them and the triangular mouth-plate. Upper arm-plates oblong, much wider than long; the lower have their distal ends much encroached on by the side-plates; the spines are quite stout, and the lowest is long enough to reach the free edge of the plate next in front.

Colour, when dried or in spirit, pale brown, with eight or nine rings of a yellowish hue at distances along each arm; bands or patches of a yellowish colour on the disc.

Diameter of disc 7 mm.; 6; 5. 13 mm., 10 mm., 7-8 mm.

Length of arm 60.5 mm. (broken a little); 60 (ca.); 50.

Macclesfield Bank, 13-35 fms.

OPHIOTHRIX.

As may be supposed, there were a large number of examples of this genus in the collection; how many species are represented it is quite impossible to say, but I have determined twelve with very great difficulty. My experience in this particular is, however, no different to that of any other zoologist who attempts to name specimens of this remarkable genus—unless, indeed, he be one who has no knowledge at all of its peculiarities. No one who has dredged our common British *Ophiothrix*, and has seen how varied are its colours and the characters of its spinulation, will attempt to name exotic specimens with a light heart. It would, of course, be easy enough to do so if one were to take no note of the experience gained by a study of British specimens, for with a few specimens one can always make new species. With considerations such as these before me, it will be no matter for wonder that I have refrained from describing any “new species” from the present collection. To confess the whole truth, I had intended to make an exception in favour of a remarkably coloured and fairly well represented species from Macclesfield Bank. When, however, it was compared with *O. purpurea*, with which, indeed, I had at first no idea of comparing it, I found that the new specimens and the old so intergraded that there could be no doubt they were one and all members of an almost protean species.

It would be worth the while of a student with unlimited leisure—and less, I fear, will hardly do—to work out large series of *Ophiothrix*. In saying this I should like to add that the late Dr. Brock made a very useful beginning in his essay on “Die Ophiuridenfauna des indischen Archipels”¹.

It has sometimes been supposed that colour is a good guide in the identification of species of this genus. Thus no less an authority on Ophiuroids than Dr. Lütken writes:—“Le système général de coloration constitue un caractère important qu’il ne faut pas négliger dans la distinction spécifique des *Ophiothrix*”². Or, if I may trust myself to translate the fuller Danish text,

¹ Zeitschr. f. wiss. Zool. xlvii.; see especially pp. 511 & 516.

² Danske Vid. Selsk. Skrift. viii. (1869) p. 104.

Dr. Lütken's view is expressed thus¹ :—" One has some help in this difficult work from colour-markings, but it is not to be understood that all individuals of the same species present the same colour, or have quite the same design (Tegning); but as a rule one will find that every species has its characteristic pattern or system, in the details of which it rarely makes exceptions."

While much of this is true, it is on the other hand perfectly certain that any one who attempts to name species of *Ophiothrix* with colour or pattern as his guide will soon find he can make very little way. I can, indeed, only repeat and enforce what I said in 1884² on this point. For example, *Ophiothrix martensi* was said by its describer, Lyman, to be bright indigo on the dorsal surface of the disc, but there is in the present collection a specimen which is light green.

The identification of specimens of *Ophiothrix* is such a difficult matter that it is unnecessary to express the hope that other workers will imitate my reserve. The difficulty is to get any one to work at the genus at all!

OPHIOPTERON ELEGANS.

Ophiopteron elegans, Ludwig, Zeitschr. f. wiss. Zool. xlvii. (1888) p. 459.

Mr. Bassett-Smith is to be warmly congratulated on taking examples of this species, which is known only from the single well-preserved and the one ill-preserved specimen brought to Europe by the late Dr. J. Brock, and fully described by Prof. Ludwig in 1888. I have made a careful examination of the seven specimens in the present collection, and have nothing material to add to Prof. Ludwig's account. I notice, however, a pinkish hue on the dorsal surface of the arms.

The examples were taken at various depths between 23 and 47 fathoms.

The most remarkable and interesting find of Mr. Bassett-Smith when on the 'Egeria' was an Ophiurid, of which it is difficult to exactly assign the systematic position.

Description of the Specimen.—With the general appearance of a young *Astrophyton* (see Plate XXVII.), the joints of the arms are distinctly marked off from one another by brown lines; the joints of the more distal branches are slightly coiled on themselves, but the more proximal trunks and branches appear to be quite stiff. The disc is covered above and below by a number of plates; there are teeth and mouth-papillæ; the bursal clefts are small and on the side of the arm, or in the same position as in *Trichaster* or *Astrophyton*. The surface of the arms is coarsely granular, and there are spiny hooks at the side of the arm; so that there is so far no essential difference from the typical *Astrophytid* structure.

¹ Tom. cit. p. 51.

² Report . . . Voyage H.M.S. 'Alert' (London, 1884). See particularly pp. 117, 141 & 142.

When, however, we come to closely examine the disc we find it to present an arrangement of plates that is quite unknown in any Astrophytid; for there is on it a set of plates which cannot be supposed to be anything but the remnants of a calycinal system¹ (see fig. 3, *c* & *r*); the centre of the disc is occupied by a rounded plate, and midway between it and the base of every arm but one there is a plate which cannot but be the homologue of the radial plate; just as distinctly there is to be seen at the base of the arms a pair of plates which are surely the so-called radial shields². Though radial shields are not diagnostic of Ophiuroids, for they are, at any rate, absent from such simple Streptophiuræ as *Neoplax*, they are exceedingly characteristic of the group, and are of large size in Cladophiurans³. In the specimen before us they exhibit some irregularity, but they do not present the characteristic of the Cladophiuran; they are not "rippenartig" and they do not extend over the whole semi-diameter of the disc. Their smaller size may be correlated with the presence of calycinal plates, the existence of which in true Cladophiurans has only indistinctly been hinted at by Mr. Lyman; but the result is that we have an almost typical Zygophiuran disc, above. On the lower surface the arrangement of the mouth-plates (Plate XXVII. figs. 4 & 5) is most nearly paralleled among known forms by *Trichaster palmiferus*, and I know of nothing resembling it that has been detected in any fossil form; the distinctness of the two halves of the oral apparatus is very marked, and must be supposed to be a primitive character.

With regard to the systematic position of this very remarkable form, I feel inclined, after much reflection, to adopt an attitude of reserve; some years since I should not have hesitated in taking it to be the type of, at least, a new family. But, if it be true that "cælum, non animum, mutant qui trans mare currunt," it is equally true that the "fugaces anni" carry away with them the cause of many a bad new species or group. It is possible still to use the diagnoses propounded in 1892 for the Cladophiuræ⁴, as the size and extent of radial shields is not there used as a diagnostic character. So far as the descent of the Cladophiuræ is

¹ That is, by those who accept the doctrines first broached by Lovén and enforced with such vigour in this country by my lamented friend Dr. Herbert Carpenter. I understand that there is, among the younger workers, some scepticism as to the validity of these homologies.

[Since this was written Mr. E. W. MacBride has published an abstract of his observations on the organogeny of *Asterina gibbosa* (Proc. Roy. Soc. Lond. liv. pp. 431-6). I am sure many morphologists await with interest the proofs of his statement that there is no homology between the abactinal poles of Crinoids and Asteroids.]

² If we are to continue to recognize homologues of the radials of the Crinoid calyx (see P. H. Carpenter, Quart. Journ. Micr. Sci. xxiv. (1884) p. 1), it might be well to make some alteration in nomenclature, as the presence of "radial" plates and "radial" shields on the same disc is confusing. It is obvious enough that Johannes Müller, the first user of both the terms, had no idea of any homologies between the Crinoid calyx and the Ophiuroid disc.

³ Is it quite certain that what are called radial shields in Cladophiurans are homologous with the parts called by the same name in Zygophiurans?

⁴ P. Z. S. 1892, p. 180.

concerned *Ophiocrene* seems to show that some ancestor of this group was provided with distinct radial shields, the presence or absence of which is so variable a character in the Streptophiuræ, which I have, I think, shown to be ancestral to the Cladophiuræ.

OPHIocreNE¹.

An Ophiuroid with branching arms and the habit of an Astrophytid, but with calycinal plates on the disc, and rounded radial shields of comparatively small size.

OPHIocreNE *ÆNIGMA*, sp. nov. (Plate XXVII. figs. 1-5.)

As there is only one specimen, and that small, it is impossible to say whether or no it is adult. It may be provisionally defined thus:—Small, with delicate arms and few branches, of a milky-white colour, the joints separated by fine brown lines.

Macclesfield Bank, 45 fms.

It may be pointed out that, at present, there is no evidence that would justify us in regarding this as the young of some already known Astrophytid of large size, but it is quite within the bounds of possibility that a series of stages may show it to be so.

V. ECHINOIDEA.

TEMNOPLEURUS BOTHRYOIDES.

Pleurechinus bothryoides, A. Agass. Chall. Rep. Ech. iii. p. 108 (1881).

Temnopleurus bothryoides, Bell, Rep. Voy. 'Alert' (1884) p. 119.

It is quite clear that this is by no means a rare species; the 'Challenger' and the 'Alert' both brought home examples, and the 'Egeria' took it in at least four dredgings between 40 and 47 fathoms. In the smallest specimen, which is not 4 mm. in diameter, the deep and extensive pitting characteristic of the species is quite well marked.

I have a pretty strong conviction that the progress of research will result in showing that *Pleurechinus variabilis* and *P. ruber* of Dr. Döderlein are synonyms of this variable species.

TEMNOPLEURUS REYNAUDI.

Temnopleurus reynaudi, Agass.

An examination of two specimens covered with spines confirms me in the view I expressed in 1880² that *T. reynaudi* and *T. granulatus* are distinct species. The examples now before me are somewhat larger than the spined specimens collected by H.M.S. 'Challenger'; the spines are rather long, creamy white, with bands of red, or with the free end red.

¹ As the word *Egeria* has been several times used in Zoology, and as κρήνη means a fountain, and *Egeria* was, it is said, changed into a fountain by Diana, I have, in this roundabout fashion, succeeded in associating H.M.S. 'Egeria' with this interesting genus.

² P. Z. S. 1880, p. 424.

SALMACIS RUFA, sp. nov. (Plate XXVI. figs. 2 & 3.)

There are several specimens of what I take to be an undescribed species of *Salmacis*. It may be diagnosed as follows:—

Spines pale whitish, with red rings or bands of inconstant breadth. Denuded test bright red, with patches of white more numerous within than between the poriferous zones. Test rather flat, not stout, circular, with a rather small mouth distinctly depressed. Primary tubercles small and numerous; only one row in each vertical set of plates extends from pole to pole, but at and below the ambitus each plate has a transverse row of four or five tubercles in the interambulacral and of two or three in the ambulacral areas. There are about 27 primary tubercles in a row in a specimen measuring 32 mm. in diameter. The anal area is chiefly occupied by a few large plates; the madreporite is of proportionately large size, and the 'oculars' are ordinarily shut out from the edge of the anal space. The edge of the mouth is deeply inflexed, and the cuts are wide but not very deep. In a specimen in which the lantern of Aristotle was examined, the teeth were found to project very little from the alveolus; this was stout and wide, with two deep grooves, and had the tooth connected with it by a descending but not by an ascending process. The apophysis is almost straight.

Diam.	Height.	Diameter of		
		Calyc. area.	Periproct.	Peristome.
32 mm.	16	6·5	2·5	8·5

Hab. Macclesfield Bank, between 30 and 44 fms.

It is a somewhat difficult matter to suggest what are the nearest allies of this species; although the characters just enumerated appear to be constant for the fairly large number of examples which were collected, none of them are of large size, and, possibly, better grown specimens will throw more light on this question.

TRIPNEUSTES GRATILLA.

Echinus gratilla, Linn. Syst. Nat. x. (1758) p. 664.

Tripneustes gratilla, Lovén, Bih. Svensk. Vet.-Akad. Hdlgr. xiii. iv. no. 5 (1887) p. 77.

An interesting young example of this species was taken in 30-40 fms.; its proportions are somewhat different to the smallest specimen I was able to measure some years since (see P. Z. S. 1879, p. 662).

Absol. diam. in millim.	Height.	Percentage value of			
		Abact. system.	Anal system.	Act. system.	Porif. zone.
28	69	23	12·5	30	8·2

LAGANUM DECAGONALE. (Plate XXVI. figs. 4 & 5.)

Scutella decagonalis, de Bl. Dict. Sci. Nat., s. v. *Scutella*, p. 229.

A fine series of this species, commencing with specimens less

than half an inch in diameter, shows that the form of the test is at first circular rather than decagonal. So far it bears out the remark of Prof. Alex. Agassiz, who, speaking of *Peronella orbicularis*, says (Rev. Ech. p. 521), "I have but little doubt that this species will prove to be the young of *Peronella decagonalis*"; at any rate, the series shows that when sufficiently small specimens are obtained they differ in form from the adult. Whether the type of Leske's species corresponds with any one of these I am unable to say. I sent the drawing here reproduced to Prof. Selenka at Erlangen, as I imagined that Leske's type was in the University Museum there¹. Dr. Fleischmann, who was kind enough to attend to my letter in Prof. Selenka's absence, says:—"Das Originalexemplar zu *Echinodiscus orbicularis* war, wie ich den alten Catalogen entnehme, niemals in Erlangen. Wie besetzen nur Originalexemplare der Kleins'chen Sammlung." Leske compares his specimen with a Zeeschelling, and Mr. Grueber, of the Department of Coins, who has been kind enough to measure a Zeeschilling for me, tells me it is .65 inch in diameter. The specimen here drawn has about that diameter, but has already ceased to be truly orbicular.

It is impossible, therefore, to speak certainly, but I think we may safely take it that *L. orbiculare* is the young of *L. decagonale*; this at any rate is certain—a set of specimens collected on Macclesfield Bank form a continuous series, of which the smaller are circular and the larger decagonal in form.

ARACHNOIDES PLACENTA.

Echinus placenta, Linn. Syst. Nat. x. (1758) p. 666.

Though commonly taken in distinctly southern waters as those of New Zealand and Australia, this species has already been recorded from Luzon, and is known as far west as Burmah and Mergui. Not only therefore has it a wide intertropical range, but it is found south of the tropics; it is to be regretted that on p. 171 of the 'Alert' Report I put a sign against the name of this species which indicated that it was not known south of the tropics.

EXPLANATION OF THE PLATES.

PLATE XXIII.

- Fig. 1. *Eudiocrinus granulatus*, to show the habit of the species, $\times 2$.
 2. A portion of an arm from above (joints 14–20). $\times 6$.
 3. The most proximal joints of the arm, with their pinnules, $\times 4$.
 4. The seventh pinnule, to show the form and ornamentation of the joints, $\times 12$.
 5. One of the most distal pinnules, $\times 12$.
 6. A cirrus, $\times 4$.
 7. The distal joints of a cirrus, $\times 12$.

PLATE XXIV.

- Fig. 1. *Antedon bassett-smithi* $\times 2$, showing the disc and the bases of the arms with Sz, the first brachial syzygy, varying in position.
 2. Side view of arm of do., $\times 2$.
 3. A cirrus, $\times 2$.
 4. 1st pinnule, to show the form of the joints, $\times 4$.
 5 & 6. 2nd and 3rd pinnules, to show the form of the basal joints, $\times 8$.

¹ See Agassiz, Rev. Ech. p. ix.

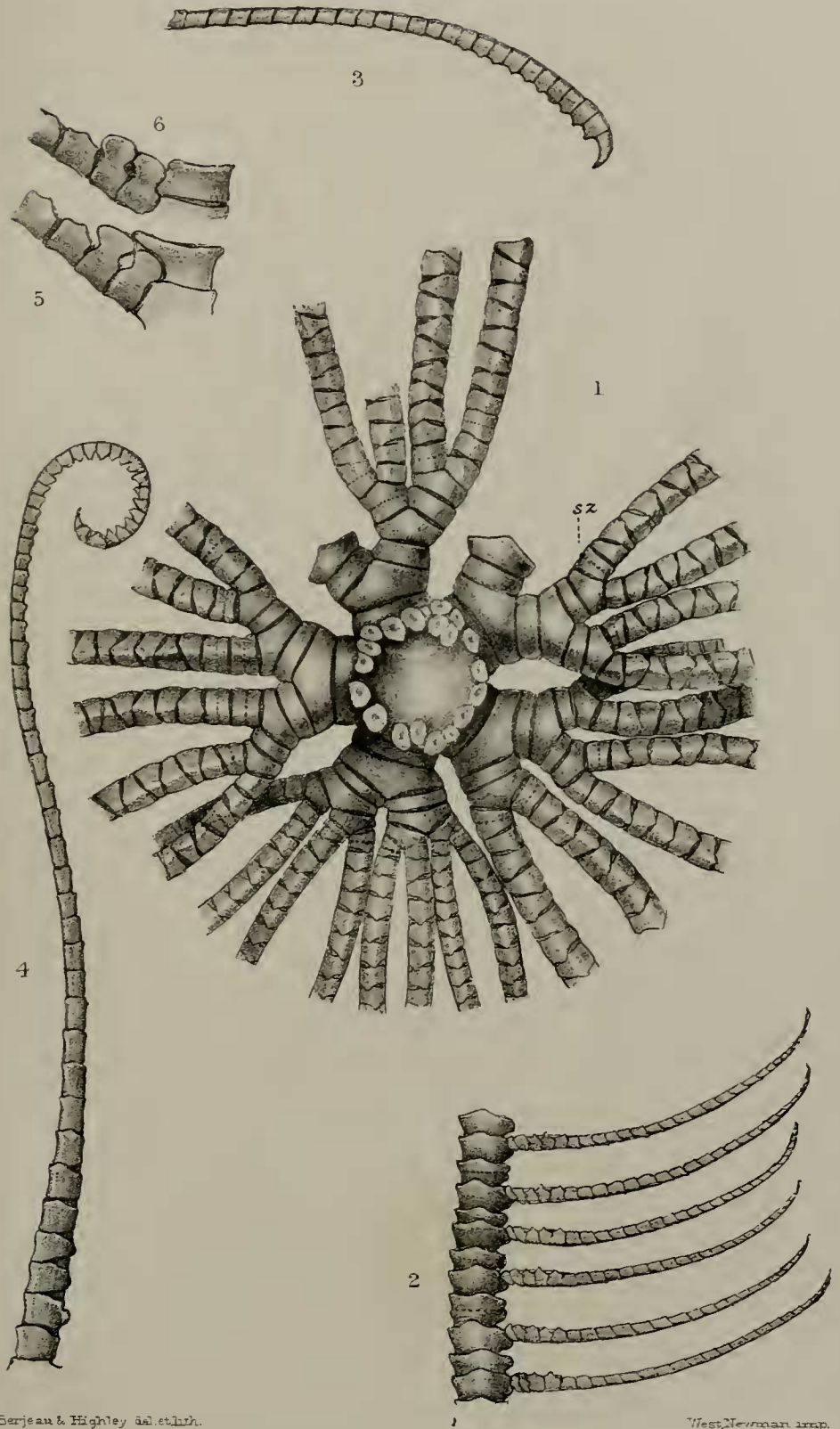


Berjeau & Highley del et lith

West, Newman imp

Eudiocerinus granulatus.





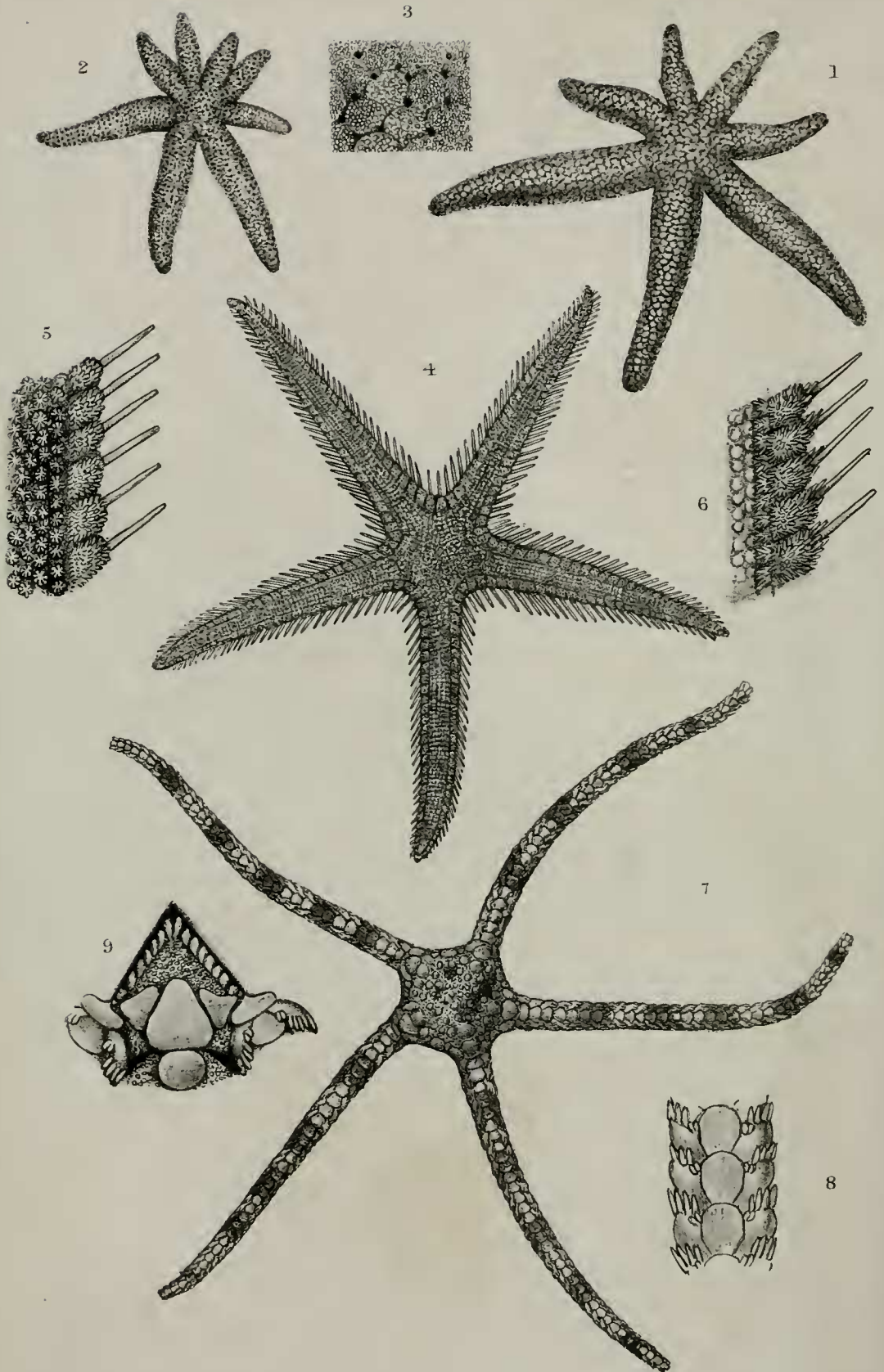
Berjeau & Highley del. et lith.

West Newman imp.

Antedon bassett-smithi.





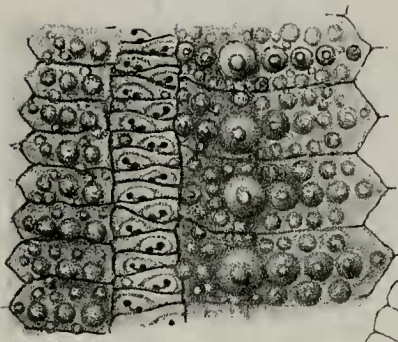


Barjeau & Highley del. et lith

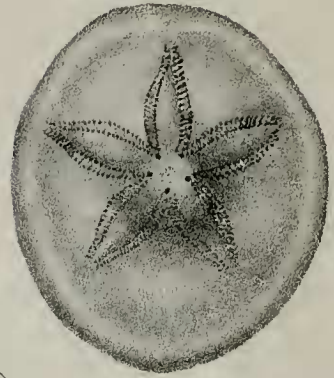
West, Newman imp

1-3. *Patiria briareus*. 4-6. *Archaster tenuis*.
7-9. *Pectinura sphenisci*.

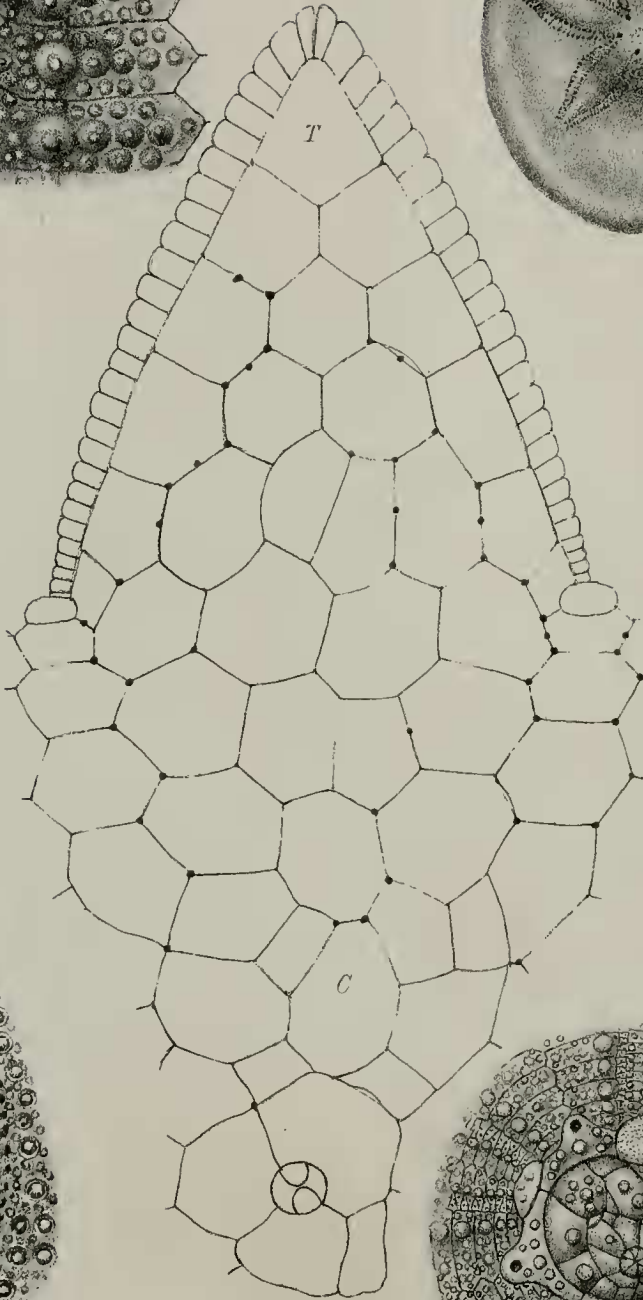




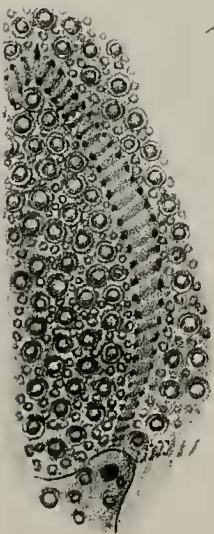
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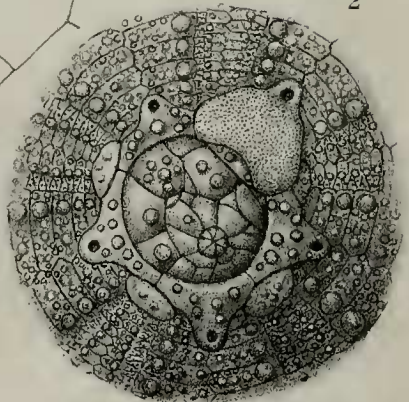
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1



5



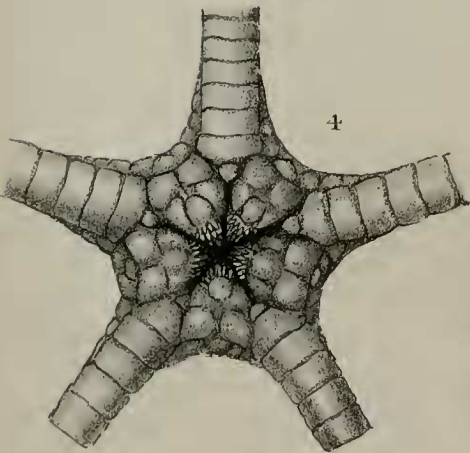
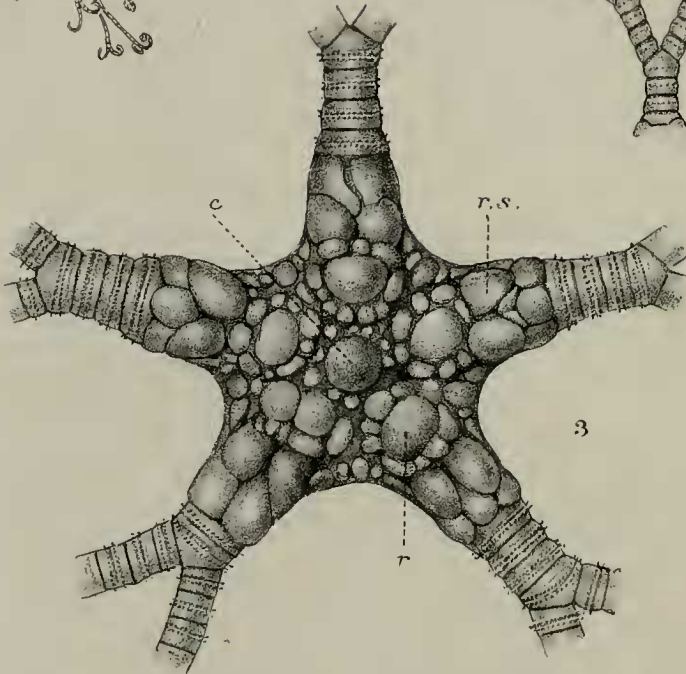
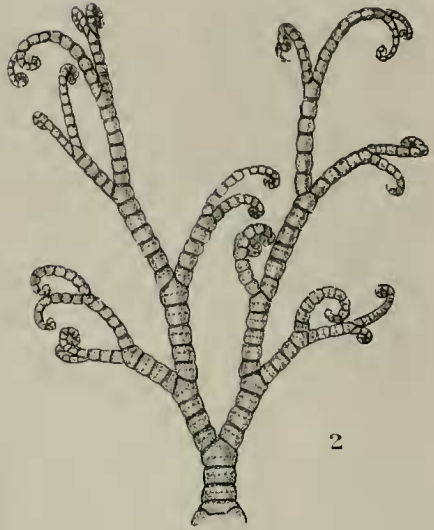
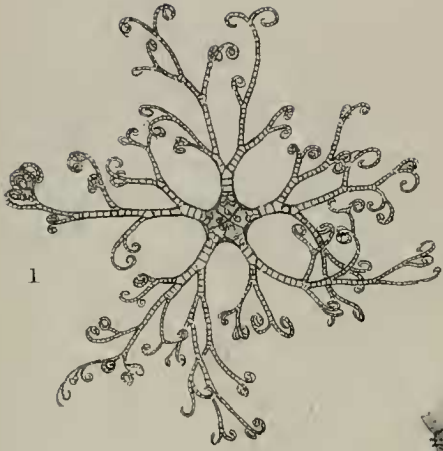
2

Berjeau & Highley del. ethh.

West, Newman imp.

1. Culcita. - 2. 3. Salmacis rufa.
4 & 5. Laganum decagonale.





Barjeau & Highley del. et lith

West, Newman imp

Ophiocrene enigma.

PLATE XXV.

- Figs. 1 & 2. Two views of *Patirio briareus* from above, to show the habit of the species, nat. size.
- Fig. 3. Part of arm of do. from above, to show the character of the granulation, $\times 4$.
4. *Archaster tenuis* from above, $\times 2$.
5. Part of arm of do. from below, $\times 4$.
6. Part of arm of do. from above, $\times 4$.
7. *Pectinura sphenisci* from above, $\times 2$.
8. Part of arm of do. from below, $\times 4$.
9. An angle of the mouth of do., $\times 8$.

PLATE XXVI.

- Fig. 1. A figure of a young *Culcita* set out from the region of the apical pole to the mouth, so as to show all the plates of rather more than $\frac{1}{3}$ th of the whole test, $\times 8$; *C*, supposed central plate, *T* the terminal.
2. Apical area of *Salmacis rufa*, $\times 3$.
3. Portion of test of do., $\times 3$, to show ornamentation.
4. A small specimen of *Laganum decagonale* (*L. orbiculare*), $\times 2$.
5. Part of petal of same, to show ornamentation, $\times 8$.

PLATE XXVII.

- Fig. 1. *Ophiocrene ænigma* seen from above, of the natural size.
2. One of the arms of the same, $\times 3$, to show the mode of branching and the form of the arm-joints.
3. The disc and bases of the arms of the same from above, $\times 8$, showing the central calycinal plate (*c*), the radial plates of the calyx (*r*), the radial shields (*r.s.*).
4. The disc and bases of the arms of the same from below, to show the general relations of the parts of the peristomial area, $\times 6$.
5. One mouth-angle, $\times 24$, to show the teeth and the oral plates and deep median cleft.

2. Studies in Teleostean Morphology from the Marine Laboratory at Cleethorpes.¹ By ERNEST W. L. HOLT, Naturalist on Staff, M.B. Assoc.²

[Received March 7, 1894.]

(Plates XXVIII.-XXX.)

I. ON SOME SPECIMENS OF THE BIRKELÄNGE (*Molva abyssorum*, Nilsson) FROM ICELAND AND FAROE.

Principal References and Synonymy.

Byrkelänge, Ström, Trondhj. Handl. iii. p. 446, tab. 8; Sönd. Beskriv. ii. p. 275.

Molva abyssorum, Nilsson, Prodröm. Ichth. Scand. p. 466; Günther, Cat. Fish. Brit. Mus. iv. p. 362.

Molva byrkelänge, Collett, Norg. Fisk. p. 116; Lilljeborg, Sver. o. Norg. Fisk. ii. p. 139.

¹ In virtue of an arrangement between the Marine Biological Association and the Marine Fisheries Society of Grimsby, the laboratory, which belongs to the latter body, is at present under the control of the Association for the prosecution of investigations dealing with the North Sea fisheries.

² Communicated by Dr. GÜNTHER and Prof. HOWES.

Molva dipterygia, Smitt, Hist. Skand. Fishes, ed. ii. p. 521, pl. xxvi. fig. 3.

Introduction.

The specific name adopted by Collett and Lilljeborg originated with Walbaum ('Petri Artedi sveci Genera Piscium,' 1792, p. 135), and is therefore older than Nilsson's name, the date of which is 1832. Professor Smitt identifies the fish with the *Gadus dipterygius* of Pennant (Introd. Arct. Zool. ed. ii. vol. i. p. cxxiv), which is not included in the synonymy by the other Scandinavian authors referred to.

The retention of Nilsson's name, as the earliest in post-Linnæan literature, is justified by the rules of scientific nomenclature, and, since it is used in Günther's catalogue and in the 'Challenger' monograph, appears to be for the convenience of British readers.

At the time this paper was written the only drawing of the species with which I was acquainted was that given by Ström (*op. cit.*). The work of this author is sufficiently rare, and his figure, though accurate enough, is merely a small outline. One of my chief objects was therefore to put forward a recognizable figure in a publication easy of access to British readers, while at the same time extending the known horizontal range of the species, and recording certain anatomical peculiarities which had escaped the notice of previous writers.

Within the last few months, however, ichthyological literature has been enriched by the appearance of Professor Smitt's new edition of Fries, Ekström, and Sundevall's 'History of the Scandinavian Fishes.' This contains a description, with figure, of the species under consideration.

The text, as I think, is not so complete as to render my own remarks altogether superfluous, the more especially since only Skandinavian examples were known to the author, while the figure differs from all examples known to me in rather important details (to be referred to below). It being too late to so far rewrite my remarks as to incorporate the whole of the necessary references to Smitt's work in the text, I have interpolated them chiefly in the form of notes.

The resemblance borne by the Mediterranean form, *M. elongata* (Risso)¹, to the species now under discussion has attracted the attention of Lilljeborg, who gives a careful comparison of the measurements of specimens of each species. He notes that a difference exists in the texture of the scales, and is unable to establish their complete identity. It would appear, from his description, that the Mediterranean form approaches the Faroë and Iceland specimens of *M. abyssorum* in the reduction of the caudal peduncle, a point in which it differs somewhat from Skandinavian examples. While inclined to suppose that the characters

¹ *Lotta elongata*, Risso, Faun. Eur. Mérid. iii. p. 217, fig. 47; Costa, Faun. del regno di Napoli, Pesc. i. p. 15, tav. xxxviii.

which separate the species may ultimately prove of less than specific value, I do not feel justified, in the face of the opinion of so accurate an observer as Lilljeborg, in including *M. elongata* in my synonymy. I have never had the opportunity of examining an example of this form, and am acquainted with no description of its anatomy.

Distribution.

The species is known to occur along the whole of the western coast of Scandinavia and in the Cattegat, but does not seem to have been observed elsewhere. It is a deep-water fish, abundant between 100 and 300 fathoms in that region¹. Of the examples before me, seven in number, two came from the neighbourhood of Ingolfs Hofde Huk, on the south coast of Iceland, in the summer of 1892. One of these was taken on a long-line, in the immediate neighbourhood of the 100-fathom line, in company with another example, which did not come into my hands. The other was trawled, at a depth which certainly could not have greatly exceeded 40 fathoms, and may very probably have been considerably less. I am indebted for these two specimens to the courtesy of Messrs. W. Hoole and F. Barrett respectively. My other five examples I bought in the Grimsby Fish-market in December 1893, and ascertained that they had all been taken in one shot of the long-lines at about 160 fathoms, 28 miles N.W. of Fugaelo, Faroë Islands.

From the information of fishermen it appears that specimens are taken from time to time on the Faroë "Bank," but are sufficiently rare to be unknown to many who regularly work that region. I could hear of no previous instance of the fish having been taken off the coast of Iceland.

The Birkelänge is one of those forms which our fishermen regard as hybrids, the imputed parents being the Hake (*Merluccius vulgaris*) and the Common Ling (*Molva abyssorum*), whilst taint of Conger blood is sometimes suggested.

The fish appears to be used as food in Norway, but, according to Mr. Hoole, who made culinary experiment of one which fell into his hands, it is very rank, and the flesh of one which I had removed for osteological purposes failed to commend itself to the not very delicate palate of a seal. Smitt, however (*op cit.* p. 524), remarks that the fish is more esteemed, when fresh, than the Common Ling, so that tastes would appear to differ. The Scandinavian vernacular name, which means "Trade Ling," is cited as testifying to the commercial value of the species.

Diagnosis of Species.

Head and body elongate, covered with minute imbricating scales. The length of the head contained about five times in the total length without the caudal fin, and much greater than the height

¹ Also at 35 and 80 fathoms (Smitt).

of the body. The length of the eye, greater than its height, contained about five times in the length of the head, and once and a half or nearly twice in the length of the preorbital region. *The length of the eye always greater than the width of the interorbital space*, which is usually less than the height of the eye, but may be equal to or even a little greater than that measurement. *The lower jaw the longer, projecting beyond the snout*, the barbel small, much less than the length of the eye. *The height of the caudal peduncle less than the height of the eye*. The vent opposite about the seventh or ninth ray of the second dorsal. The mouth more or less closely speckled with black chromatophores.

The italics are intended to denote such characters as serve at a glance to distinguish this species from the Common Ling (*M. vulgaris*, Fleming), and the close resemblance which the Birkelänge bears to that well-known form renders it unnecessary to elaborate the diagnosis further.

The diagnosis is based on the examination of the seven specimens forming the subject of this note, which range in total length from 42 to 50½ inches. Hence it may not be strictly applicable to smaller examples, since the proportions, especially those of the eye, are subject to developmental changes in all fish. I am led by this to suppose that Lilljeborg, who describes the interorbital space as much less than the height of the eye, may have based his remarks on the examination of smaller fish; but it is quite possible that a variation in this, as apparently in some other respects, exists between Scandinavian and more Western examples of this species.

The condition exhibited by my specimens renders it also probable that the relative length of the lower jaw increases with the size of the fish, so that in young examples it may even be less than that of the upper jaw¹. We know this to be the case in the Coal-fish (*Gadus virens*), in which the lower only passes the upper jaw when a length of about twelve to fifteen inches has been attained. There remain, however, other characters sufficiently well marked to distinguish the species at any size. The Birkelänge is not known to reach a length greater than 60 inches², and is therefore a much smaller fish than the Common Ling.

¹ It may be remarked that very large Common Ling occasionally exhibit an infinitesimal projection of the lower jaw. Such a projection is given by Lilljeborg as a specific character in the case of the species before us. Smitt, however, states that in all his specimens the upper jaw was distinctly the longer, and his figure (*op. cit.* pl. xxvi. fig. 3) shows this condition clearly enough. From internal evidence the material forming the subject of his remarks seems to have consisted of four examples, stated to be adult, ranging in size from 56.2 to 82.8 cm., and therefore all smaller than our Iceland and Faroë specimens. It is, nevertheless, by no means clear that all small examples have the snout projecting, as Lilljeborg (*op. cit.* iii. Append. p. 787) mentions an example of 60 cm. without qualifying his previous remarks on the conformation. On the whole it seems most probable that the majority of adults, whether from Scandinavian or other waters, have the lower jaw the longer.

² Smitt (*op. cit.* p. 522) observes that the species seldom exceeds a length of one metre (39 inches *ca.*), but it does not appear that his acquaintance with this fish is very extensive.

The fin-ray formula is enumerated by Lilljeborg as follows :—

DI. 13-14. DII. 78-85. A. 75-80. Pelv. 5-6.

The examples before me give

DI. 12-15. DII. 69-75. A. 70-74. Pelv. 6-7.¹

The difference in the number of rays in the second dorsal and anal is considerable, but the small number of my specimens and the absence of any information as to the number represented in Lilljeborg's formula render it impossible to say whether such difference is indicative of local variation, or depends on nothing more important than chance.

Description of the Specimens.

I append a table of dimensions, since such facts are often of more importance in the eyes of an ichthyologist than an author's deductions therefrom. The specimens A to E are those from Faroë, and the measurements were taken from the fresh condition; the Iceland examples, *x* and *y*, were measured after preservation in alcohol.

The anterior extremity as here denoted is the extremity of the lower jaw when the mouth is closed. The measurements are given in inches.

Specimen	A	B	C	D	E	<i>x</i>	<i>y</i>
Total length	50 $\frac{1}{2}$	49 $\frac{1}{4}$	47 $\frac{1}{8}$	46 $\frac{1}{2}$	42	47	46
Total length without caudal...	47 $\frac{1}{2}$	47	44 $\frac{3}{8}$	45 $\frac{1}{2}$	39 $\frac{1}{2}$	44	42 $\frac{3}{4}$
Length of head	10 $\frac{1}{4}$	10 $\frac{1}{4}$	9 $\frac{3}{4}$	9 $\frac{1}{4}$	8 $\frac{1}{4}$	9	9 $\frac{1}{4}$
Preorbital length	3 $\frac{3}{4}$	3 $\frac{1}{2}$	3 $\frac{1}{2}$	3 $\frac{1}{4}$	3	3	3 $\frac{1}{4}$
Horizontal diameter of eye ...	2	2 $\frac{1}{8}$	2 $\frac{1}{8}$	2	1 $\frac{3}{4}$	2	2
Vertical diameter of eye	1 $\frac{3}{4}$	1 $\frac{1}{8}$	1 $\frac{3}{8}$	1 $\frac{3}{4}$	1 $\frac{3}{8}$	1 $\frac{3}{8}$	1 $\frac{3}{8}$
Width of interorbital space...	1 $\frac{1}{2}$	1 $\frac{3}{8}$	1 $\frac{7}{8}$	1 $\frac{7}{8}$	1 $\frac{1}{6}$	1 $\frac{5}{16}$	1 $\frac{1}{4}$
Greatest height of body	5 $\frac{7}{8}$	5 $\frac{1}{2}$	5 $\frac{3}{4}$	6 ²	5 $\frac{1}{8}$	5ca	5ca
Greatest girth of body.....	13 $\frac{1}{2}$	15	15	13 ²	12 $\frac{1}{2}$		
Height of caudal peduncle ...	1 $\frac{3}{8}$	1 $\frac{3}{8}$	1 $\frac{3}{8}$	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1 $\frac{3}{16}$	1 $\frac{3}{8}$
Ant. extremity to 1st dorsal...	14 $\frac{1}{4}$	13 $\frac{1}{2}$	13 $\frac{3}{8}$	12 $\frac{1}{4}$	11 $\frac{1}{8}$	13	12 $\frac{1}{8}$
Ant. extremity to 2nd dorsal.	18 $\frac{3}{8}$	17 $\frac{3}{4}$	17 $\frac{1}{8}$	16 $\frac{5}{8}$	14 $\frac{7}{8}$	17	16 $\frac{1}{4}$
Ant. extremity to anus	22	22	21	20 $\frac{1}{2}$	18	19	20
Length of pectoral	5	4 $\frac{1}{2}$	4 $\frac{3}{4}$	4 $\frac{3}{4}$	4 $\frac{1}{4}$	4 $\frac{5}{8}$	4 $\frac{5}{8}$
Length of pelvic	4 $\frac{1}{8}$	4 $\frac{1}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	4	3 $\frac{3}{4}$
Length of barbel	?	$\frac{6}{8}$	$\frac{9}{16}$	$\frac{1}{2}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{16}$

The lower jaw projects from $\frac{1}{8}$ to $\frac{3}{4}$ inch beyond the upper, and the angle of the gape reaches to about a vertical from the centre of the eye. The teeth are not distinguishable either in structure

¹ For purposes of comparison I append the fin-ray and vertebral formula of *M. vulgaris*, taken from Lilljeborg (*op. cit.* pp. 131 and 137), as dealing with the most Northern examples as to which information is available :—

DI. 13-16. DII. 62-70. A. 57-66. Vert. 64-65.

² The eversion of the stomach in this specimen renders the value of these measurements uncertain.

or arrangement from those of the Common Ling, but the large teeth of the inner row of the mandible and of the vomer, which exhibit the lateral compression and spatulation of the points most strongly, are fewer in number by comparison with Common Ling of the same size; this is due, no doubt, to the latter being considerably younger than the examples before us. The tongue is broad and free, with a sharp anterior edge. There are about 80 pores in the lateral line.

Colours.—The dorsal region of the head and body is a brownish slate colour, shading ventrally into a brownish grey on the sides, which have a cupreous lustre in very fresh examples, and becoming nearly white in several examples in the ventral abdominal region. The jaws and under surface of the head brownish grey, the branchiostegal membrane not darker than the surrounding region, but the tip of the lower jaw and barbel dark. A dark spot on the axilla; the pectoral dark slate-grey; the pelvic pale, but speckled with dark pigment. The dorsals slate-grey, both fins darkest in the submarginal region, especially the posterior part of the second dorsal; the extreme margin light, nearly white in some examples. The anal resembling the second dorsal, but fading into a pale slate colour anteriorly. All these fins have a bluish lustre on their darker parts. The mucous membrane of the mouth may be almost colourless, but is usually rather profusely speckled with black pigment. I am told that it is sometimes black, but have not seen any specimen to which such description would apply. The peritoneum of the body-cavity dark grey or black.

The Birkelänge thus differs conspicuously enough from Ling taken from the comparatively shallow water in our own seas; but comparing it with Faroë specimens of that species, I find that the principal difference (so far as concerns external pigmentation) that can be affirmed is that the commoner form is rather the paler of the two. We know from Lilljeborg¹ that the two species resemble each other in being more vividly coloured in the young condition than when adult.

In order to emphasize the external differences of the two species I have appended a figure of both. The Ling (Plate XXVIII, fig. 2) is actually some ten inches shorter than the Birkelänge (fig. 1), and, the figures being drawn to such scales as to be practically of the same size, the difference in the size of the eyes is not so marked as it would be had examples of the same actual length been represented, since the size of the eye varies in inverse ratio to that of the individual. Nevertheless the eye is seen to be largest in the Birkelänge, and its relatively greater length as compared with that of the head is still more conspicuous. Such dimensions as the height of the body and of the caudal peduncle in relation to the total length are practically constant during the interval of size which separates the two specimens, and consequently the value of the figures for purposes of comparison is not thereby impaired.

¹ This author (*op. cit.* iii. Append. p. 787) describes the coloration of an example of *M. abyssorum* 60 cm. long.

Anatomical Features.

The Alimentary Viscera.—The abdominal cavity is much elongated, extending back rather beyond the first third of the anal fin, and terminating in a narrow process, the apex of which, in a specimen $47\frac{1}{8}$ inches long, is 32 inches from the snout. The alimentary tract, as compared with that of the Common Ling, exhibits features of some interest. The cardiac portion of the stomach, which, as in the Ling, is prolonged backwards beyond the small bulbous pyloric portion, occupies the whole length of the visceral cavity except the narrow canal-like process already referred to. It is extremely thin-walled and flaccid, and thus in marked contrast to the firm muscular stomach of the Ling. The pyloric cæca are numerous, as in the Ling, but somewhat larger. The delicacy of the walls may be said to be characteristic of the whole of the alimentary canal in the Birkelänge. It reaches its maximum in that part of the intestine which is beyond the origin of the pyloric cæca. The walls are here so thin as to be ruptured at the slightest attempt to lift the gut, and, in one specimen, were found to have been ruptured before the visceral cavity was opened. The intestine is very much shorter, as well as more delicate, than in the Ling, as will be readily understood by a glance at Plate XXIX. figs. 3 and 4¹. It also appears to be subject to variation in its arrangement, the condition in two examples, both females, being shown in figs. 3 and 3 a. The liver is very much larger than in the Ling. It consists of a single ventral lobe, in which the coalescence of lateral elements appears to be indicated by the presence of deep sulci. It is somewhat expanded anteriorly, while the posterior process appears to pass indifferently either to the right or left of the rectum. In the Gadidæ a greater development of the liver seems to be frequently characteristic of the more abysmal members of a genus. The mesenteries are as stout as in the Ling.

The Air-bladder.—This is a simple fusiform structure, occupying the roof of the abdominal cavity from the anterior extremity to the origin of the ureter. It differs from that of the Ling chiefly in that its anterior cornua, which lie external to the attachments of the pharyngeal muscles to the vertebral column, possess no lumen, and that its dorsal wall is somewhat more spongy and less definite than that of the commoner species. The rete mirabile, a single structure, 4 inches long by 1 inch broad in a specimen $47\frac{1}{8}$ inches long, occupies the usual position, and is, if anything, a little smaller than in the Ling.

The Kidneys.—These terminate posteriorly in a small expanded process, from which the ureter passes obliquely forward to the region of the vent. The posterior process is much larger in the Ling, and blocks the narrow end of the visceral cavity. On the

¹ Smitt (*op. cit.* p. 524), in a very brief account of the visceral anatomy, notes that no part of the intestine, in a male 65 cm. long, extended beyond the anus.

other hand, in the Birkelänge the so-called head-kidney is more definite in outline, and its histological structure leaves no doubt that it is perfectly functional. In the Ling the proportion of reniform matter is much less, but the head-kidney does not appear to be wholly functionless.

The Reproductive Organs.—Three specimens examined proved to be females. The ovaries are much like those of the Ling. From their condition it appears probable that the species spawns off Iceland and Faroë late in the summer or in the autumn.

The Skeleton.—One of the Faroë specimens has 78 vertebrae, the first complete hæmal arch occurring on the 32nd. Lilljeborg gives the total number as 78–79, of which 30–31 belong to the trunk. In other respects the skeleton is much like that of the Ling.

Morphological Considerations.

It appears that we have before us a form very closely allied to the common species, and in which almost all the distinctive characters are illustrative of specialization along one definite line. To take them *seriatim*, we may consider first the relative length of the jaws.

The protrusion of the lower jaw is a feature most obviously associated with the feeding-habits of the fish, and the fact that the Northern Gadoids usually exhibit this character might be found, could the matter be satisfactorily investigated, to indicate nothing more than that the food-supply available in the higher latitudes is not adapted to the requirements of bottom-feeders. At the same time the protrusion of the lower jaw in the larvæ of all Teleosteans that have been studied may indicate that this condition in the adult has an ancestral significance, such fish as exhibit it being in this respect less specialized than others which do not, though here again the pelagic habit of the said larvæ may go far to prove the character to be merely one of adaptation. Thus, like most other scientific facts in the present state of our ignorance, we may derive therefrom whatever interpretation appears most convenient to preconceived theory. That there is no necessary connection in Gadoids between this character and an abysmal habitat is sufficiently demonstrated by the Macruridæ, but the fact remains that such association usually exists in the less specialized members of the group (cf. *Merluccius*, *Mora*, &c.). The reduction of the barbel is a character so obviously related to the elongation of the lower jaw that it requires no separate discussion, since it is difficult to see what benefit an "underhung" fish could derive from such an appendage, however well developed. Nevertheless the presence of a well-developed and functional barbel in the closely-allied species with the shorter mandible almost forces us to regard the appendage in *M. abyssorum* as vestigial, and, if that be admitted, it is not difficult to arrive at a conclusion as to which condition of the jaws is least indicative of specialization.

The next feature is the relative size of the eye, and it may at once be said that in the enlargement of this organ *M. abyssorum* exhibits a character equally associated in Gadoids with either an abysmal or a Boreal habitat. *Gadus saida* may be taken as an instance of the last, as one of the few Gadoids which are known to be confined to Northern regions and which have not hitherto been met with in deep water. Speaking generally, it may be said that all Gadoids have rather large eyes, and it is questionable whether their reduction in the more littoral forms, such as some of the *Motellæ*, may not be as much illustrative of modification in one direction as their enlargement in the deep-sea forms appears to be in another. This group of fishes appears, in fact, to be the present representatives of a stock that had become adapted for life at moderate depths rather than in either deep water or at the extreme margin.

With regard to the characters of the alimentary viscera a reduction of the length of the gut has been shown by Dr. Günther¹ to characterize a deep-sea member of the Percoid fishes; but I am not aware of any observation that bears on the relative strength of the walls of the intestine. It is evident, however, from their fragility in the species before us that life would be impossible in a region exposed to any violent action of the tide, nor is it easy to understand that the fish could display any great activity, without risk of internal injury. That it is not an active fish, as compared with its congener, may be judged from the reduction of the caudal peduncle and fin, and by the attenuation of the whole caudal region, a character we find invariably present both in deep-sea and Northern Gadoids. The same may be said of the elongation of the body, which carries with it the increase in the number of the vertebræ and of the rays of the dorsal and anal fins, and it will be remembered that Collett found a constant increase in the number of these structures in the more Northern examples of a series of *Hippoglossoides platessoides*².

A point which appears worthy of a moment's notice is the pigmentation of the mucous membrane of the mouth and of the peritoneum. It is a matter of common knowledge that these structures are more or less black in deep-sea fishes, whereas in their more littoral allies they are usually destitute of dark pigment, and this is well illustrated by comparing the two species of *Molva*. We know that whatever light there may be in the abysses of the ocean is at all events not directly derived from that which illuminates the surface. Without committing ourselves to an opinion of the value of any particular theory, we may be inclined to accept the broad fact that there is a connection between light and pigmentation, and, in the case of flat-fishes, we are familiar with attempts which have been made from time to time, with more or less success, to demonstrate this connection. Passing from external to internal pigmentation, if we open the

¹ 'Challenger' Reports, vol. xxii. p. 14.

² 'Norwegian North Atlantic Expedition, Fishes,' Christiania, 1880, p. 147.

abdominal cavity of a flat-fish, we find that the peritoneum of the ocular side is beset with dark pigment, while that of the blind side is not. It seems clear enough that whatever cause governs the presence or absence of external pigment in these fishes is equally potent with regard to the dark pigment of the internal region¹. If this cause be the light, we have in the condition of round-fishes an apparent anomaly, not in the absence of pigment from the peritoneum in littoral fishes, since the difference of position involves a much greater interruption of the light from above, but in its conspicuous development in the deep-sea fishes, the peritoneum of which can be in no way subject to any action of the sun's light.

In conclusion it may be remarked that *M. abyssorum* is a form such as might well be descended from a parent stock not greatly differing from the Common Ling of the present day, and that the extensive vertical range of that species would appear to offer facilities for the establishment of such an abysmal offshoot².

II. ON THE RECESSUS ORBITALIS, AN ACCESSORY VISUAL ORGAN IN PLEURONECTID FISHES.

In making an examination of the cephalic anatomy of the

¹ Since this was written, I find that Messrs. Cunningham and MacMunn, in their monograph "On the Coloration of the Skins of Fishes" (Phil. Trans. 1894, p. 809), consider that the "difference can only be explained as the effect of light falling on the upper side of the fish, and not on the lower." I omit further reference to their results, since they are discussed at some length in No. II. of this series of papers.

² It is interesting to find that Professor Smitt (*op. cit.* p. 525) arrives at a precisely opposite conclusion, viz., that "from a systematic and genetic point of view, *M. dipterygia* must be regarded essentially as a predecessor of the Common Ling, though the former has evidently adopted in certain respects a distinct direction of development from the common original type which we are entitled to assume." "This," he remarks, appears from an appended table of averages of certain measurements in the two species. No further explanation being forthcoming, I am unable to say in what way the table may be supposed to support his conclusions, nor am I inclined to attach any great value to a series of averages based in no case on more than three specimens.

The right of the author to form any opinion he chooses, as to the relative antiquity of the types of structure exhibited by the two species, is undoubted; but it seems impossible to limit its application, and the logical conclusion is, that if Smitt holds this opinion in the present instance, he also regards all Gadoids which exhibit an abysmal type of structure as more primitive than their littoral brethren. This view is, of course, in direct opposition to that held, as I suppose, by all other ichthyologists, viz., that the abysmal forms are descended from littoral ancestors.

Elsewhere (p. 520) Smitt notes that the trace of division in the second dorsal fin is more marked in the Birkelänge than in the Common Ling, but it does not appear that this was taken into consideration in formulating the conclusion quoted above. To most ichthyologists it would appear as rather important evidence as to the greater antiquity of the type exhibited by the commoner species. Again, when dealing with *Gadus esmarkii*, the author considers that the persistence of the barbel brings that species nearer to the common origin of the Cods than the Pollack, which has no barbel (p. 499), so that the same facts would appear, in the hands of Professor Smitt, to be capable of diametrically opposite interpretations.

Common Sole, my attention was arrested by a sac-like structure lying immediately behind the lower eye, external to the membranous wall of the orbital cavity. The absence of any mention of such a structure in Cunningham's monograph of that species¹ suggested that the specimen under examination might be in that respect abnormal; but I have since found it in every Sole which I have examined, and there can be no doubt but that it is a regular feature in the anatomy of the species.

The organ in question is almost certainly homologous with a rounded process of the membranous wall of the orbital cavity discovered by Dr. Günther² in *Chorisochismus dentex*, one of the Gobiesocidæ, and conjectured by him to represent the *saccus lacrymalis* of higher animals. Beyond this I have been able to find no reference to the existence of any structure at all corresponding to that now under consideration.

It was my intention, before publishing, to work out the development of the organ as completely as possible, since any opinion that might be formed as to the homologies of the structure would be of little value unless supported by a knowledge of its ontogeny. The material at my command, however, has proved unsuitable for the purpose, and, since some considerable time must elapse before fresh specimens of the required stages are available, I have thought it best to put forward such information as I have already collected, imperfect as it is, in order to attract the attention of others who may find themselves in a position more favourable for the prosecution of the inquiry.

I have ventured to apply to the organ the name (*Recessus orbitalis*) which appears at the head of this section.

Distribution in Species.

I have found the organ present, in some form or another, in every species of flat-fish examined for this purpose, and believe that it will be found to occur in all. The species examined comprise the Halibut (*Hippoglossus vulgaris*), Long Rough Dab (*Hippoglossoides platessoides*), Plaice (*Pleuronectes platessa*), Flounder (*P. flesus*), Common Dab (*P. limanda*), Lemon "Sole" (*P. microcephalus*), Common Sole (*Solea vulgaris*), and Brill (*Rhombus levis*).

Topography and Structure.

The organ consists usually of a sac-like process of the membranous wall of the orbit, and in all the forms mentioned, except the Halibut, both orbits are furnished with such a process. The condition in the Plaice may be taken as fairly representative of that met with in the genera *Pleuronectes*, *Hippoglossoides*, and *Solea*, so far as their anatomy is known to me in this respect.

¹ 'A Treatise on the Common Sole,' Plymouth, 1890.

² Cat. Fish Brit. Mus. vol. iii. p. 490.

The organ of the lower orbit—*i. e.*, that belonging to the ocular side of the body, in this case the right side—may be found immediately under the skin overlying the membranous wall of the orbital cavity just behind the eye. To expose it without rupture requires rather careful handling, as, in the fresh condition, the organ is extremely delicate, and it is bound to the skin anteriorly by connective tissue. It is generally of a roughly trihedral outline, occupying a space bounded dorsally by the backward prolongation of the interorbital ridge of the skull, anteriorly by the eye, and postero-ventrally by the anterior face of the superficial jaw-muscles of the same side. To expose it fully it is necessary to remove a part of these muscles. The organ will then present much the appearance shown in figure 5 (Plate XXX.), according to the state of expansion. Various branches of the V-cranial nerve, which, for the sake of clearness, are omitted from the figure, will be seen in its neighbourhood, mostly passing internal to it. The distribution of these branches varies somewhat in the different species, but usually two small branches pass to the external face of the organ, which receives its nervous supply from one of them. In the Sole the course of the nerves not infrequently affects the shape of the sac, which may assume a bilobate or even a trilobate appearance therefrom.

The sac is almost translucent in very fresh examples, save for certain milky-white streaks observable about the periphery. It is smooth externally, and firmly bound on its inner face to the wall of the orbital cavity. If the internal structure is exposed, by a partial removal of the outer wall, as shown in Plate XXX. figure 6, it will be seen that a number of white muscular bands are attached to the inner surface of the walls, which are otherwise extremely thin and delicate, while other bands traverse the lumen, either independently, or so associated together as to form more or less definite septa. The bands on the walls, while they interlace with each other in all directions, show nevertheless some attempt at a radiate disposition around an orifice which communicates with the orbital cavity itself. There may be more than one such orifice; in fact, in the specimen figured there are two of considerable size (*o.*, *o.*), while several smaller ones are hidden by the septum (*s.*). Even in cases where only one distinct orifice occurs, which is perhaps the commonest condition in the Plaice and Common Sole, I am not certain that minute openings do not also occur in its neighbourhood. The larger opening, or openings, always show a distinctly thickened rim. The specimen figured appeared to be completely subdivided by the septum, but this is not of constant occurrence in the species. Indeed, in speaking of the dextral forms which I have studied, it is only possible to say of the internal structure of the accessory organ of their lower orbit that it is more or less subdivided by muscular septa, and communicates with the orbital cavity by one or more openings, placed close together, of which one is always distinctly larger than the rest. It is advisable, in studying this structure, to partially harden it by an injection of

alcohol previous to dissection, owing to its great contractility in the perfectly fresh condition.

In fresh examples the organ will be found to contain a colourless fluid, which becomes a milky-white coagulum when the fish is rather stale. The same fluid exists also in the orbital cavity, and it can readily be passed from one to the other by pressure. The organ, owing to its internal structure, will be found to be extremely elastic, and this elasticity is retained to some extent for a considerable time after death. In figure 5 the organ is shown in a moderate state of expansion, slight pressure being applied to the eye at the time of drawing. Inflated with air the organ becomes singularly lung-like, the resemblance being even more marked in the case of its fellow of the blind side.

The organ is rather more developed in *Pleuronectes* than in *Solea*, otherwise there is no important difference between the two genera. In the Brill the organ of the lower eye is much smaller than in *Pleuronectes* and *Solea*. The membranous wall of the orbital cavity, otherwise undifferentiated, expands in a conical process behind the eye, and the apex of this process is furnished with internal muscular bands similar to those met with in the definite sac-like organ of *Pleuronectes*. There does not seem to be a definite narrow opening between the muscular apex and the rest of the conical process of the Brill, and the whole apparatus is not very conspicuous unless pressure is applied to the orbital cavity.

The lower orbital cavity of the Halibut is destitute of a definite sac-like process, but a portion of its membranous wall is differentiated. On removing the skin behind the eye, more or less fibrous and a great deal of adipose matter is found to overlie the orbital cavity. Removing this, the membranous wall, otherwise translucent, is seen to exhibit a trihedral opaque whitish patch in the position occupied in *Pleuronectes* by the sac, or a little posterior thereto. It is seen that the orbital membrane is thickened by the development of a number of minute lobules or sacculi. Their saccular nature is easily proved by inflating the orbital cavity, which causes them to stand out distinctly. They collapse again as soon as the pressure is reduced, and cannot be expanded by merely depressing the orbit. Examination of the internal surface of this part of the membranous wall shows a complex arrangement of white muscular bands, forming a network pierced by numerous smaller and larger orifices, one, in a specimen examined, being considerably larger than the rest. The structure is thus essentially the same as that of the organ in *Pleuronectes*, the only difference being in the number of orifices by which the organ communicates with the general lumen of the orbital cavity. A small branch of the V-cranial distinctly terminates on the outer face of the differentiated area.

The organ of the upper orbit, that belonging morphologically to the blind side of the body, is saccular in all *Pleuronectids* which I have examined, and is invariably larger than that belonging to the ocular side. It is always situate on the blind side, communi-

cating with the cavity of the orbit to which it belongs through a foramen in the skull. In all but *Rhombus*, the organ lies partly in front of the superficial jaw-muscles, immediately under the skin, and partly between those muscles and the skull. In figure 8 the organ of the Halibut is displayed by the removal of the anterior part of the muscles, and by clearing away such part of a great pad of adipose matter as interfered with the view. It is seen that the organ is divisible into an anterior and a posterior limb, the division being due to the effort of the organ to accommodate itself to the available room—viz., in front of and internal to the muscles named. An arrow shows the passage of the anterior limb to a funicular region leading to the foramen through which access is gained to the general orbital cavity. The foramen in question is that between the parasphenoid and the bony bridge formed by the union of the ectethmoid and sphenotic of the blind side; it also gives exit to a palatonasal branch of the V-cranial.

The organ of the blind side in its internal structure is similar to that of the ocular side in such forms as *Pleuronectes* and *Solea*. It is somewhat noticeable that it is rather larger in the Halibut than in any of the species which possess a definite sac-like organ of the ocular side, but the description given for the Halibut is sufficiently applicable to all the forms enumerated except the Brill. In this species the difference is brought about by the more forward extension of the jaw-muscles, which completely overlies the organ. In consequence it is flattened: it is semicircular in outline, the arc being ventral, and communicates with the orbital cavity by a short narrow neck arising from the centre of its dorsal surface. It is smaller than that of any other species mentioned, but agrees with them in internal structure, and is considerably larger than its fellow of the opposite side.

Figure 7 of Plate XXX. shows a dissection which exposes the upper, or left, orbital cavity in the Plaice, a dextral flat-fish, by the removal of a great part of the right and left frontals, including the whole of the bony interorbital septum, and of the right and part of the left ectethmoid. It is seen that the orbital cavities are now separated only by the fibrous band which forms the internal (morphologically ventral) continuation of the interorbital septum. The recti muscles and the optic nerve have been cut through, and the membranous wall of the cavity has been slit along the margins of the eye to allow of the latter being turned forwards. The orbital cavity is thus fully exposed; it is seen to be roughly ovoidal in shape, with a conspicuous funnel-like depression on the left side near the posterior end. The membranous wall, which lines the whole of the cavity, is continued into this funnel, which is the opening into the accessory organ which we have already studied from the other side. A seeker can readily be passed through the opening, and the organ can easily be injected with fluid through the medium of the orbital cavity. It is worthy of notice that the upper orbital cavity is bounded on most sides by structures which yield little or not at all to pressure. In front and behind

are the solid walls of the skull ; below is the interorbital septum ; above, the firm dorsal muscles and anterior interneural spines. On the left or inner side are the coalesced limbs of the left ectethmoid and sphenotic, separated from the parasphenoid by the foramen already mentioned. Thus expansion is only possible on the right or outer side, occupied by the eye, and on such part of the left or inner side as is pierced by the foramen.

The organ is rather richly supplied with blood by a branch coming from the vessel corresponding to the external carotid artery of higher animals. This branch passes to the inner face of the organ, whether left or right, and breaks up into numerous smaller vessels on that surface.

I have already mentioned the large pad of adipose tissue which underlies and more or less surrounds the left organ in the Halibut. It consists optically of a mass of connective tissue very closely beset with minute oleaginous globules. The whole is more or less elastic, and must add considerably to the contractility of the organ it surrounds. To a less extent adipose matter is found in the neighbourhood of the organ of the blind side in most species which I have examined.

I have studied the internal structure of the organ in various species in the ordinary way, by means of microscopic sections, but can find no trace of any glandular structure. The walls of the organ and the interlacing muscular bands are merely lined with ordinary flat epithelium cells. The liquid noticed as occurring both in the organ and in the general orbital cavity is coagulated, by the action of reagents, into a finely granular plasma, taking on a faint pink stain in borax-carmin. It is indistinguishable optically from the substance met with in similar preparations of some of the brain-cavities of young fish.

Professor Howes has drawn my attention to the fact that a similar fluid is met with in mesenteric and synovial cavities, and, in the absence of any definite secretory apparatus, is assumed to be deposited there by the blood-vessels through the medium of the ordinary epithelium cells. It seems permissible to draw the same inference in the case of the organ now under discussion, and to consider that the richness of the blood-supply is associated with the production of the fluid. Similar fluid is present in the orbital cavities of fish in which the *recessus* is not developed, but of course in a less quantity.

Function.

We have seen that the cavity of the orbit and of the *recessus orbitalis* is filled during life with a fluid which has, without doubt, the function of supporting the orbit, since the sinking of the eyes which is always, unless averted by artificial means, to be observed in stale fish, seems to be chiefly due to the coagulation and consequent shrinkage of the fluid contents of the orbital cavities.

It will be familiar to most observers that, whereas in a "round

fish" like the Cod the movements of the eye are such as can easily be attributed to the action of the eye-muscles, in flat fish, and especially in the genus *Pleuronectes*, when the fish is at rest or on the look-out for food, the eyes are considerably elevated above the rest of the head. If the fish is frightened by placing some object near the eyes, the latter are suddenly withdrawn into their sockets, but quickly rise again as soon as the cause of terror is removed. By close observation it may be seen that the retraction of the eyes is accompanied by a simultaneous swelling immediately behind the lower eye, *i. e.* in the region occupied by the *recessus orbitalis* of that eye. The swelling disappears with the subsequent elevation of the eye. If a fresh fish is taken, and the skin removed as in Plate XXX. fig. 5, it will be seen that pressure on the lower eye has the effect of filling the *recessus*, but that as soon as the pressure is relaxed the organ empties itself back into the orbital cavity and the eye rises again. The same connection between the elevation of the eye and the elasticity of the *recessus* can be demonstrated in the case of the upper orbit, by pressure of the upper eye in either a living or a moderately fresh specimen, and no doubt the voluntary retraction of the upper eye when the fish is frightened is accompanied by a swelling of the region of the *recessus* on the blind side. I have not seen this, having no vessel suitable for making the experiment.

Now the eye is an organ of considerable weight, and is furnished with no protractor muscle, and it is impossible that such considerable protraction as one actually observes in the eyes of flat fishes can be effected by the mere relaxation of the oblique and recti muscles.

Further, if the *recessus* of the upper orbit becomes in any way ruptured, the fish is no longer capable of elevating the upper eye, though its fellow continues to be raised and lowered as before.

We have seen that the structure of the *recessus* is such as to impart the greatest possible amount of elasticity to that organ, and I think that beyond doubt its function is simply to protract the eye and to regulate its vertical movements. It acts, as it were, after the fashion of a "push-ball." Assuming the protracted condition of the eye to be the normal state, it is obvious that it could not be retracted, even partly, into the orbital cavity without displacing a corresponding amount of the fluid contents of the latter. In the absence of a special diverticulum this would involve a stretching of the undifferentiated membranous wall; and though this structure is to a certain extent elastic, it is obvious that the stretching could not take place unless the cavity were entirely or mainly surrounded by non-resistant bodies. This, however, as we have seen when examining the topographical anatomy of the *recessus*, is not the case.

It therefore follows that to admit of the retraction of the eye a special diverticulum must exist for the reception of the orbital fluid, and this we find in the *recessus*.

The eye being retracted, we have seen that there is no apparatus

more potent than the relaxation of the recti and oblique muscles to re-effect its protraction, and here again the elastic nature of the *recessus* completely supplies the want.

The action therefore, except in so far as it is, or may be, concerned in the deposition of the orbital fluid, is purely mechanical, and appears to be almost, if not quite, involuntary. I qualify the statement thus because it appears to me that flat-fish have their eyes very slightly more elevated when expectant of food than at other times. A fish of the genus *Pleuronectes* usually shows that it anticipates food by bending its body into a crescent shape, the head and tail off the ground, ready for an instant dart; but the greater degree of elevation of the eyes under such circumstances may in reality only signify that a slight contraction of the orbital muscles is characteristic of the resting condition.

An involuntary organ might be expected to show some connection with the sympathetic system, but such a connection I have not found, though I am far from stating that it does not occur. The only nervous supply with which I am acquainted is that derived from the V-cranial, but whether from sensory or motor roots, or from both, is a point which I have not yet investigated. We have seen that the organ is most developed in *Pleuronectes*, moderately so in *Solea*, and least developed in *Rhombus*; and I can say from observation that the power of elevating the eyes is precisely in the same proportion in those three genera. I have had no opportunity of studying the habits of *Hippoglossoides*, as the Long Rough Dab is very difficult to obtain in a healthy condition. The habits of the Halibut are also unknown to me in this respect; but the fact that it shows the maximum development of the left or upper accessory organ and the minimum development of the right or lower organ, amongst the series of forms which I have studied, is very probably due to the greater difference in the level of its eyes, or of its orbital cavities, than in other flat-fishes. The ocular surface of the head is very convex, while the left eye never gets far beyond the ridge, and is consequently at a much lower plane than the right eye. To bring the two eyes to the same level, if that condition is actually attained by the living fish, must certainly need a greater inequality in the elevating apparatus than prevails in any other flat-fish known to me.

The fact that the *recessus* of the eye belonging morphologically to the blind side is the larger of the two in all the species studied is susceptible of a very simple explanation. The eye of the ocular side, the lower eye, has its orbital cavity bounded on the outer side in great part by loose skin and connective tissue, thus allowing whatever elasticity may be possessed by the undifferentiated membranous wall in this region to come into full play when the eye-muscles are contracted. The elasticity of the skin, combining with the pressure of the external element over a surface greater than that of the eye itself, must certainly afford some assistance in elevating the eye as soon as the muscles are relaxed.

In the case of the upper orbit, however, no such aid is forth-

coming. We have seen, when examining fig. 3, that the orbital cavity is bounded by walls which are practically rigid. It would in fact be impossible for the eye to be retracted at all if the cavity had no such secondary chamber as is furnished by the *recessus*, and it is therefore by no means surprising that this structure is always most developed in the orbit in question.

The position of the *recessus* of the upper eye on the side of the head to which this eye morphologically belongs seems to indicate that the organ is developed before the union of the ectethmoid and sphenotic of the blind side, a union which does not take place until after the eye has crossed the ridge¹.

Conclusions.

The function of the *recessus orbitalis* seems sufficiently clear, but its homologies must remain in doubt for the present. It is almost certainly homologous with the pouch-like diverticulum of the membranous wall of the orbit discovered by Dr. Günther in *Chorisochismus dentex*. I have examined the examples of this fish which are contained in the National collection and have made a dissection of one. The organ exhibits no features not noted by Dr. Günther, except that it is rather flattened in the case of my specimen. It occupies a position immediately below the eye in a rather large subdermal cavity, which is plainly visible through the skin in all examples. The orifice by which it communicates with the orbital cavity is of moderate width, perhaps wider than in the case of any flat-fish which I have studied. Internally I could see no distinct muscular bands; but the walls of the sac are rather stout, and appear to be muscular. As the specimen has been for many years in alcohol, which had no means of reaching the sac except through the tissues, it is quite possible that the internal parts may be to some extent altered by decomposition, and that muscular bands similar to those of the *recessus* in flat-fish may have originally been present. Slight pressure of the eye caused the discharge into the sac of a considerable amount of opaque yellowish matter, evidently decomposed tissue of some sort.

It is evident, by comparison of the specimens, that the eye is capable of some vertical movement, and it appears most likely that the sac is functional in the same way as the *recessus*.

The difference in position is merely such as might be brought about by the rotation of the eyes in Pleuronectids. This is plainly indicated in the posterior displacement which takes place in the choroidal notch of the lower eye in a metamorphosing flat-fish larva, and the *recessus* in the adult appears merely to have retained

¹ Since this was written my attention has been drawn by Professor Howes to some observations of Dr. Georg Pfeffer (Verh. Deutsch. zool. Gesell. 1894, p. 83), in which the formation of a bony orbital wall on the blind side of the upper eye is recorded as a regular feature in the development of the skull after that eye has completed its transit.

what was presumably its original relationship to the morphologically ventral side of the eye.

Dr. Günther considered that the structure he described might represent a *saccus lacrymalis*, but I do not see there is any reason to regard the *recessus* of flat-fishes in that light. The *saccus* is a superficial structure developed altogether outside the eye, never acquiring any but a topographical (and physiological) relationship therewith. It is always in intimate relationship with the lacrymal scute; but no flat-fish with which I am acquainted possesses anything that can be homologized with this scute, while such other fishes as I have examined, which do exhibit structures to which that name has been applied, show no trace of an accessory visual organ.

The lacrymal gland suggested itself to me at one time as a possible homologue; but beyond a certain similarity of position, of innervation, and of blood-supply, there is little evidence in favour of this hypothesis either. The lacrymal gland arises in Mammalia as a solid outgrowth of the conjunctival epithelium into the underlying connective tissue, subsequently becoming hollowed out to form the cavities of the gland and ducts¹, and never enters into any relations with the inner orbital cavity. Of the development of the *recessus* I have no knowledge; but if it is ever connected with the conjunctival region, the position of the organ of the upper orbit shows that this connection must be lost at a very early period prior to the migration of the eye. If a gland at all, it is destitute of glandular epithelium, or, at all events, I have failed to find any.

It is, of course, equally possible that a gland might in process of evolution take on new functions and lose its glandular nature, or that a non-glandular ancestral structure might become specialized for a glandular function; but, in the absence of any information as to the origin of the lacrymal gland of higher animals, speculation on this point is more or less idle.

From what we have seen of the anatomy of the *recessus* in its fully developed condition, it appears to me most reasonable to regard it merely as a part of the ordinary membranous wall of the orbital cavity, specialized to perform certain definite functions in connection with the elevation of the orbit, and not homologous with any organ known to exist in the eye-apparatus of higher animals, and I have been guided by this opinion in my choice of a name. It may probably occur rather widely in Teleosts which have the habit of burying themselves in the sand. Of such forms I have only examined *Trachinus draco* and *T. vipera*, in both cases with negative results.

In conclusion, my thanks are due to my friend and teacher, Professor Howes, for many valuable suggestions.

¹ Cf. Kölliker, *Entwick. des Mensch.*, Leipzig, 1879, p. 699. I am indebted to my friend Mr. M. F. Woodward for this and other references bearing on the same subject.

III. ON AN ADULT SPECIMEN OF THE COMMON SOLE (*Solea vulgaris*, Quensel) WITH SYMMETRICAL EYES, WITH A DISCUSSION OF ITS BEARING ON AMBICOLORATION.

The specimen forming the subject of this note was obtained in the Grimsby Fish-market in the autumn of 1892. It was caught in the North Sea, but on which particular fishing-ground I could not find out, nor is the matter of great importance.

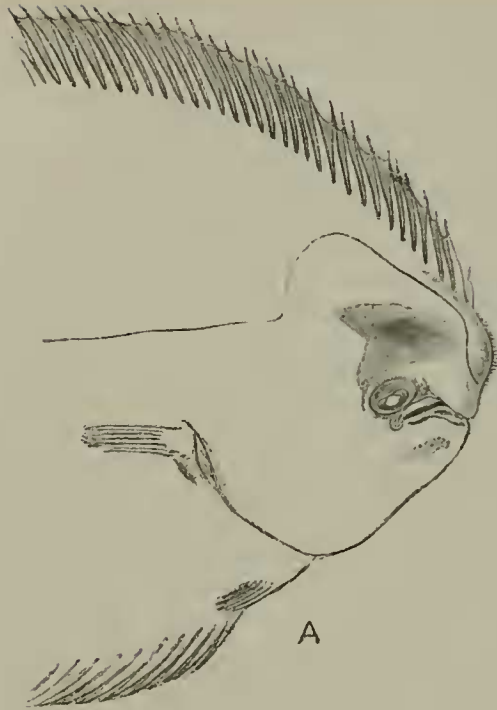
It measures $15\frac{1}{4}$ inches in total length, the head is $2\frac{1}{2}$ inches long, and the greatest height of the body is $5\frac{5}{8}$ inches. The total length without the caudal fin is $13\frac{3}{8}$ inches. The specimen may therefore be said to have the normal proportions of a Sole of that length. It is a female, and it is apparent, from the condition of the germinal epithelium and from the presence of a few ripe but decomposing ova in the ovary duct, that it had spawned in the preceding spring or summer.

Of the right or upper surface it may be sufficient to say that the only point in which it differs from a normal example is in the absence of the upper or left eye. In the normal adult of this species, as is well known, the upper eye is about an eye-length above and about half a length in front of the lower or right eye, occupying the front portion of an ovoidal depression, quite visible in living fish and even more conspicuous in spirit preparations.

In the example before us, the depression is present, but the eye is wanting. The only other point, one which would not in itself attract particular notice in an otherwise normal example, is that the final curve of the dorsal cephalic branch of the lateral line is rather less abrupt than usual. The scales being omitted in fig. A, this structure is shown as a bold line, which, of course, it is not in the actual condition. It will be understood that scales are present wherever they are found in normal examples, extending also over the site normally occupied by the upper eye. The dorsal fin extends forward to the normal extent, and the number of its rays, 87, is within the known limits of variation in normal examples of the species. The pigment of the upper side is perfectly normal.

Turning to the left or under surface, we find the divergence from the normal type again practically limited to the eye. Amongst minor points, the posterior opening of the nostril of this side is very slightly in rear of its usual position, and a downward curve of the lateral line, which, starting at the same point as the dorsal cephalic branch, passes, in some normal Soles now before me, in an almost semicircular sweep to the posterior region of the mouth, cannot be detected in the abnormal example. But as this structure, and also the dorsal branch, is altogether omitted in Cunningham's figure of the blind side¹, it may be presumed that it is not always noticeable even in normal specimens. A slight extension of pigmented and scaled skin on to the under surface of the head (fig. B) below the mouth is due, as I suppose, simply to the action

¹ 'A Treatise on the Common Sole,' Plymouth, 1890, pl. v.



A. Adult Sole with symmetrical eyes. Anterior region from right side: scales and pigment omitted. $\times \frac{1}{2}$.
B. The same from left side: scales and sensory filaments omitted. $\times \frac{1}{2}$.

of the preserving fluid. The scales and sensory filaments of the under surface are perfectly normal, subject to the trifling exception just noted, and have therefore been omitted from fig. B. It may be remarked that in North-Sea Soles filaments extend on to the bases of the first few dorsal fin rays, but otherwise have the same distribution as is depicted in Cunningham's figure.

The left eye is situated nearly opposite to the right eye, but is slightly dorsal to it, and about half a length further back. Relative to the mouth the two eyes occupy nearly the same position, the difference being accounted for by the greater length and dorsal displacement of the gape on the left side. But, whereas on the right side the whole of the iris is exposed, and the whole eye is somewhat elevated and within certain limits freely movable (either by the muscles or by the peculiar mechanism dealt with in the previous section of this paper), on the left side the eye is to a great extent embedded in the skin (see fig. B). Only about half the iris is visible, and even some part of the lens is obcluded, and the sensory filaments, which extend right up to the cornea on the ventral side, must, when erect, have considerably interfered with the animal's vision. The whole eye is antero-ventrally rotated from what we may suppose to have been its original nearly lateral aspect, and I should think the fish could see but little except in the directions indicated, while the prominence of the lips must have been a further impediment to its sight. No movement could have been possible except such as involved a general movement of the skin in this region; but, as the skin is always loose here to allow of the expansion of the accessory visual sac, one may suppose that the eye may have been shifted to whatever extent the length of the eye-muscles permitted. The appearance it presents is that of being gradually overgrown by the skin, or of being withdrawn by some internal agency within the tissues of the head.

The whole of the left surface of the fish is absolutely devoid of pigment, with the exception of a slight extension of colour below the mouth, which I have already attributed to post-mortem changes, and of certain patches of colour on the caudal fin and a small dark spot near the posterior end of the body. Such markings of the extreme posterior region of the under surface are, however, as often present as absent in normal Soles.

The left eye is as bright as its fellow of the opposite side and of the same colour, and, staring out of a dead white surface, presented rather a bizarre effect in the fresh condition.

The whiteness of the underside is perhaps one of the chief peculiarities of the specimen. The Cyclopean condition, comparatively common in the Flounder (*Pl. flesus*) and, according to my own experience, commonest of all in the Turbot (*Rh. maximus*), is always accompanied by a more or less complete pigmentation of the blind side. In fact, as has been pointed out by Cunningham and MacMunn¹, complete ambicoloration has been observed only

¹ "On the Coloration of the Skins of Fishes, especially of Pleuronectidæ," Phil. Trans. 1894, p. 806.

in specimens exhibiting the Cyclopean malformation: behind a line drawn through the preopercular keel the blind side may be almost entirely coloured in Turbot which are otherwise perfectly normal¹. Now the Cyclopean condition may be described as the failure of the anterior part of the dorsal fin, and of the interneural bones and muscles belonging to it, to become united to the top of the head, accompanied with a partial, if sometimes very slight, arrest of the normal transit of the upper eye. No one has had an opportunity of watching the development of a Flat-fish so deformed, but the variability in the different phases of metamorphosis which one notices in looking over a collection of partly symmetrical larvæ suggests a more or less plausible explanation of the mere mechanical process. Each part appears, as it were, to change independently, so that, assuming a slight want of harmony in the movement of the upper eye and the forward extension of the dorsal (whether by retardation of the first or acceleration of the last), it is conceivable that a condition might arise in which the eye would obstruct the progress of the dorsal, and so compel its anterior extremity to project instead of proceeding as usual along the top of the head. Since the dorsal wall of the upper orbit is formed in normal specimens (of the Turbot) by the base of the dorsal, the failure of the latter to advance in the normal manner would leave the eye devoid of its usual support, so that it would rest, as it actually does in Cyclopean specimens, against the ridge of the skull, and so be more dorsally and less laterally directed than in normal examples.

The authors referred to arrive at no conclusion as to why Cyclopean examples should be ambicolorate, but (p. 808) reject Giard's theory that young fish so affected remain pelagic for a longer time than usual, and so expose the blind side longer to the light, whereby it retains its pigmentation instead of becoming colourless. In this I am inclined to agree with them, but since we know from Mr. Cunningham's own observations that metamorphosing Flat-fish, if pelagic, swim in such a position as to keep both eyes in one horizontal plane², it would seem to follow that in young Cyclopean examples, the period of pelagic life being the same, the change in position is never carried to quite the same extent as in the case of normal larvæ. Hence the side normally colourless in the adult would be a little more exposed to the light, without any elongation of the pelagic period. It can hardly be contended, however, that a difference so comparatively trifling is sufficient to account for so marked a discrepancy in the coloration of all Cyclopean and most normal Turbot.

Another abnormality, exemplified by a Turbot and a Brill in my possession, is referred to by Messrs. Cunningham and McMunn (p. 807), from a description of the Brill, at that time living in the Cleethorpes aquarium, communicated by myself. In these specimens the eyes are normal, but a short portion of the anterior end

¹ See postscript, p. 446.

² Nat. Science, vol. i. March 1892.

of the dorsal is free. Besides the specimens in question, I have seen similarly malformed Turbot on several occasions in the Grimsby market, and have no doubt but that the malformation is common enough. As the authors remark, this condition differs from the Cyclopean only in degree, and I would suggest that the explanation offered above as to the process of development of the Cyclopean malformation is equally applicable to that now under consideration, allowing, of course, for a less degree of want of harmony in the metamorphosis. But, again, quoting Messrs. Cunningham and MacMunn, "it is a very great difference of degree, and does not contradict the conclusions . . . formulated as to the correlation of the typical malformation with ambicoloration." That is true enough, but since the partial malformation is not necessarily accompanied by ambicoloration, it would seem possible to restrict the correlation to the abnormality of the eyes.

The Brill, as described by the authors, is colourless on the blind side, except for a small patch of pigment just behind the notch of the dorsal, and continuous, through the notch, with the pigment of the ocular side. The inner face of the notch is rounded, there being no abrupt line of demarcation between the ocular and blind sides; and I am inclined to regard the intrusion of colour as due simply to a migration of chromatophores. Pigment commonly extends on to the blind side of the ventral part of the head in *Pl. microcephalus*, the ventral edge being in this form rounded instead of somewhat abrupt. I have also a young Plaice (*Pl. platessa*) which has in some manner been cut through down to the backbone. The wound has healed without the anterior and posterior regions re-uniting, and a certain amount of pigment extends through to the blind side. I think it may therefore be assumed that the Brill is practically normal in the coloration of the blind side.

The Turbot has a good deal of pigment on the posterior region of the blind side, but others, with a similar hook of the dorsal, I have noticed to be entirely colourless on the blind side, and pigment, as noticed by the authors referred to and others, occurs so commonly, and sometimes to so considerable an extent, on the blind side of otherwise perfectly normal Turbot that there is no reason to suppose that the malformation of the dorsal in this particular specimen has any necessary connection with its partial ambicoloration.

The authors mention the frequent occurrence of Turbot and Brill with a row of spots along the interneural and interhæmal regions of the blind side, and certainly, in the North Sea, Brill so marked are extremely plentiful. I have not observed it so commonly in Turbot, the reason being, as I supposed, that such spots are usually marked by a more or less diffuse arrangement of the pigment in ambicolorate Turbot. I do not find any suggestion that these markings of the blind side of the Brill are precisely those which are the most conspicuous in the metamorphosing and

pelagic stage, yet such, in fact, is the case. In almost all flat-fish there is a tendency, even before the yolk is absorbed, towards an arrangement of the pigment into several series of patches, transverse to the long axis of the body. Each series consists mainly of a group of chromatophores on the dorso-lateral and ventro-lateral regions of the trunk, and is completed by corresponding groups on the dorsal and ventral parts of the marginal fin¹. The pigment is, of course, equally developed on either side, and, as the body of the larva increases in depth and the basal ridges of the median fins appear, the chief colour-patches extend on to these, and ultimately come to be confined almost entirely to these areas. Between the primary patches of each ridge, secondary markings commonly make their appearance and shortly become little inferior to the original. The process is illustrated, incidentally, in the drawings of almost every author who has studied the development of flat-fish. The Brill, so far as I am acquainted with its ontogeny, exhibits these spots as conspicuously as any metamorphosing larva, and more so than the Turbot, in which the early development of a diffuse body-pigment tends to mask them somewhat. Nevertheless they are easily visible in the later pelagic stages of that form, and can be made out, even on the blind side, in a specimen the eye of which has arrived at the ridge of the head, and in which, of course, the pigment of the blind side is considerably less abundant than that of the coloured side. On the ocular side of a Brill at a similar stage of cephalic metamorphosis they are shown clearly enough by Cunningham in his 'Treatise on the Common Sole' (pl. xv. fig. 5).

In later life in both the species mentioned, as also in most other flat-fishes, the dark spots cease to be conspicuous, the lighter intervening areas being the only markings which attract attention in half-grown and adult fishes (on this part of the body). In the Topknots, however, the markings remain visible throughout life in *Rh. punctatus* and *Phr. unimaculatus*, while in full-grown *Rh. norvegicus* they are as conspicuous as in the younger stages of any Pleuronectid.

The Brill of which we have been speaking less commonly exhibit another marking on the blind side, in addition to the rows of spots on the interspinous ridges. This is situated on the lateral line rather behind the middle of the body. A mark is very usually present in this position in metamorphosing flat-fish of other species, and in the Brill it persists as a rather large roundish black spot on the ocular side in half-grown and perhaps also in full-grown fishes, though I have not myself observed it in the latter. It corresponds in position to the ocellus of *Ph. unimaculatus*, to the posterior spot of *Rh. punctatus*, and to a similar marking in *Rh. norvegicus*.

¹ Such an arrangement of the larval pigment is by no means confined to the Pleuronectidæ, and any deductions that may be drawn as to the ancestral significance of such pigmentation may probably be capable of a wider interpretation than that which, for the purposes of the present paper, I have thought necessary to suggest for them.

We have therefore, in the ambicolorate but otherwise normal Brill, a reproduction on the blind side of those markings which are most conspicuous in the young of the same and of most other species of Pleuronectids, and which are characteristic, of course on the ocular side, of the smallest species of the genus *Rhombus* and its immediate allies. I wish to draw especial attention to these facts, as I consider that they have a distinct bearing on the interpretation of the phenomenon of ambicoloration.

Mr. Cunningham, in the Royal Society memoir so frequently referred to, establishes the fact that pigment can be produced by the action of light on the colourless under surface of an already metamorphosed flat-fish, noting, at the same time, the great variation which exists in the susceptibility of individuals to this treatment. The authors reject, however, the hypothesis that the ambicolorate condition so commonly met with can also be explained as due to the action of light, since there is "not the slightest evidence at present that these abnormal specimens have been exposed to abnormal conditions, or have had abnormal habits of life," and, for my own part, I most certainly agree with them in the main. There is, however, one colour abnormality, so common as perhaps hardly to merit such a designation, which I think is probably due to the action of light. This is the presence of more or less pigment on the blind side of the median fins. It may be present merely in the form of irregular dull streaks or splashes, as in the caudal fin of the Sole, which forms the subject of this paper, or it may be developed to such an extent that practically the whole of the marginal fins are coloured. This last condition is exemplified by a Dab (*Pl. limanda*) in my possession, but the pigment of the blind is as brilliant as that of the ocular side, and there are a few bright spots on the blind side of the body as well. I find no difficulty in attributing such a dull and partial pigmentation as is present on the caudal fin of the Sole to the action of light through the transparent tissues of the fin, but the brilliant coloration of the Dab's fins, associated, as it is, with a partial, if very slight, development of colour on the non-transparent body, seems to require some further explanation.

Messrs. Cunningham and MacMunn find a difficulty in accepting reversion or atavism as an explanation of the ambicolorate condition, in that the hypothetical vertically swimming ancestor of the Flat-fish must have "had an unpigmented white or silvery ventral surface, as other symmetrical fishes have," whereas completely ambicolorate flat-fish are uniformly pigmented all over. The difficulty certainly arises if we assume that the ancestor really was paler on the ventral region than elsewhere; but is it not equally reasonable to assume a stage of evolution in which the fish resembled such forms as *Platax* or *Dascyllus*, to take instances from families widely separated from each other by systematists? Both forms have high compressed bodies, and in some species, at any rate, in both genera the ventral region is as deeply pigmented as the dorsal. Even in the John Dory (*Zeus faber*), in which the

ventral abdominal region is flattened, it is nevertheless rather darkly pigmented, and to me it certainly seems more probable that the Pleuronectidæ of the present day began to take on their asymmetrical characters as compressed and uniformly coloured forms than in the condition of ordinary round fish.

A feature which appears to me to be of the highest importance is the fact that ambicolorate fish appear to be always what one may term "ambiciliate" also. That is to say, whenever pigment is found on the blind side of a fish, the scales in that region are as rough as those of the other side (in such forms as exhibit asymmetry in this respect), or, at all events, are rougher than on the blind side of normal examples of the same species. The Turbot, for instance, which normally has no spines on the blind side, always possesses them if ambicolorate. They are usually confined to the pigmented region, but may occur also on the white part of the skin, but only, according to my own experience, in specimens which exhibit some pigmentation or other of the blind side¹.

I am not aware that it has been contended that the action of light can have any effect on the development of the spines or scales, and Mr. Cunningham's experiments yield no information on the subject, since in his most perfectly coloured Flounders (*op. cit.* pl. 53) practically no pigment manifested itself in the regions corresponding to the site of the only tubercles which British examples of *Pl. flesus* possess. If we admit the inefficacy of light in this respect, it becomes evident that we are dealing with a phenomenon in which the pigmentation is not the only element of importance. The reversion, in fact, if such it is, extends to the derma generally, and not merely to its power of producing the various elements of coloration.

I have shown² that the Turbot in its early pelagic stages is possessed of a very powerful cephalic armature, and that the larvæ of another sinistral form, perhaps the Brill, are equally well armed, though in a different manner³. It is possible to regard these cephalic spines either as protective structures, in essential relation to the pelagic period of existence, or, perhaps with greater probability, as of merely ancestral significance. In a future communication I hope to be able to show that the dermal spines or tubercles of our British Turbot are undergoing, or have undergone, a reduction in number, so that the condition of the

¹ I am speaking now of British examples only, since Turbot from the Norwegian Fjords not uncommonly possess spines on the colourless blind side. Norwegian Turbot, however, are much more profusely spined on the ocular side than their British allies, and the spinulation of the blind side, when present, is always much inferior to that of the other. I have never seen an ambicolorate example from Norway; but only a few hundred fish have come under my notice, and it is possible that "double" specimens may have been withdrawn by the consignors, since such are not supposed to have a high market value, except for naturalists. Besides being more spinous, these Turbot appear to be also considerably smaller than our own.

² Journ. M. B. Assoc. 1892, p. 402.

³ Trans. R. Dubl. Soc. v. 1893, pl. xii.

spines in the smaller Norwegian examples is the more ancient. Since symmetry of dermal armature must have been as characteristic of the hypothetical Pleuronectid ancestor as symmetry of colour, the presence of spines or tubercles on both sides of ambicolorate flat-fish seems to me an important evidence of reversion; further, the fact that when colour is present on the blind side of the Brill (and also of the Turbot, though the feature is less conspicuous) it commonly assumes the distribution characteristic of the young stages of nearly all Pleuronectids, and of the adult stages of the Topknots (the smallest and most strongly ciliated, and probably the most primitive of its allies), appears to strengthen the case considerably.

A difficulty undoubtedly arises in the want of any known instance in which ambicoloration has been accompanied by a development of the muscles of the blind side equivalent to that which takes place on the coloured side, or of equal development of the pectoral fins. The dermal tubercles, however, even in Cyclopean Turbot, are never developed on the blind side to an extent corresponding to that of the ocular side, so that at best only a partial reversion can be argued for any feature which manifests itself in ambicolorate examples.

In partially ambicolorate specimens, in which the pigment of the blind side is irregular, and not arranged in definite series of markings, as in the Brill, the theory of reversion would inculcate that the reversion to colour-activity and symmetry of scales is confined to certain areas of the derma. Total ambicoloration, as Messrs. Cunningham and MacMunn remark, has only been recorded in association with the Cyclopean condition. It appears to me that this may possibly imply that the reversion is so general that it has affected the normal metamorphosis, that there is in fact a partial reversion to symmetry of the head (as well as to symmetry of the pigment and scales) exemplified by such a want of harmony in the migrations of the eye and dorsal fin, as I have already suggested may be the mechanical cause of the Cyclopean result.

It is evident, however, from the usually normal colour condition of specimens in which the structural abnormality of the head is confined to the projection of a small part of the dorsal, that such abnormality is not necessarily accompanied by any tendency towards a reversion of pigmentation, nor does it appear to be indicative of even the slightest reversion towards symmetry of the head.

In the Sole now under consideration, as we have seen, the under surface is white. The muscles of the blind side are reduced in the normal manner, and the ciliation of the scales is feeble. The dorsal fin has completed its usual forward migration, but the eyes remain practically symmetrical.

We have seen that there is no reason to suppose that ambicolorate examples, whether Cyclopean or structurally normal, differ in any of their habits from perfectly normal fish, since Cunningham's observations of the behaviour of a living Cyclopean

Plaice rebut such a supposition, while no evidence is forthcoming in its favour. The same authority has also failed to detect any difference in the habits of partially ambicolorate but structurally normal fish. Plaice and Flounders, more or less coloured on the underside, are extremely common in the Humber, and having kept a considerable number of such fish in the Cleethorpes tanks and watched their behaviour attentively, my own experience is precisely to the same effect as Cunningham's. The young Brill, with the hooked dorsal, structurally abnormal but not ambicolorate, differed in its habits in no respect from several normal Brill of about the same size, taken at the same place, and kept in the same tank.

Of the habits of the Sole under discussion I have of course no knowledge, the fact that it was trawled in company with a number of normal examples being of little value, since I have occasionally trawled such essentially pelagic fish as Mackerel and Herrings. The complete asymmetry of everything but the eyes seems, however, to refute the idea that it could possibly have maintained a vertical position, and the complete absence of pigment from the blind side of the head and trunk would seem, in the light of Cunningham's investigations, to show that that side could not have been exposed to the light, unless the susceptibility of the individual were so slight that the power of pigment-production was practically lost by the derma of that side.

The bearing that the condition of our specimen has upon the question of ambicoloration, into which I have entered at so great a length above, appears to me to be this,—that the phenomenon of complete ambicoloration, as typified by some Cyclopean Pleuronectids, cannot be held to depend on the mere arrest of the migration of the eye, unaccompanied by other structural abnormality¹. The proposition, as laid down by Cunningham and MacMunn, that complete ambicoloration occurs only in Cyclopean examples, is in no way affected thereby, but, as it seems reasonable to suppose that any abnormality of habit (whether in the pelagic or later stages), such as Giard² considers to exist in Cyclopean Turbot, would surely be intensified in a specimen like that now before us, I should say that the theory of the French observer may be considered to be finally disposed of.

Anatomical Features.

Most of my superficial and all my subdermal observations were made after the specimen had been some months in alcohol.

On removing the skin from the right (normally the ocular) side

¹ That ambicoloration may exist in a specimen not essentially differing in external characteristics from the Sole now under consideration is shown by a young Turbot in the St. Andrews Museum, described and figured in the 'Fauna of St. Andrews Bay' by Professor McIntosh. The specimen is only a few inches in length and normally developed, except that the eyes are on different sides of the head, and pigment exists on both sides of the body.

² "Sur la Persistance partielle de la Symétrie bilatérale chez un Turbot," C. R. Soc. Biol. Jan. 22, 1892, p. 31, and Nat. Sci. i. 5, p. 358.